

Prof. D. D. Kosambi
Commemoration Volume

SCIENCE AND HUMAN PROGRESS

Essays in Humanities, Indology, Science,
Mathematics and Personal Tributes to
late Prof. Damodar Dharmanand Kosambi



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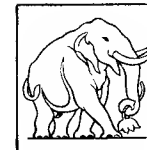
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Essays in honour of
late Prof. D. D. Kosambi
Scientist, Indologist and Humanist

SCIENCE AND HUMAN PROGRESS

Foreword by
V. V. Giri
President of India

D. D. Kosambi



POPULAR PRAKASHAN
Bombay

POPULAR PRAKASHAN PRIVATE LIMITED
35C Tardeo Road, Popular Press Building, Bombay 400 034

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First Published
1974

(3078)

Printed in India

Printed by V. P. Bhagwat at Mouj Printing Bureau
Khatau Wadi, Bombay 400 004

Published by Ramdas G. Bhatkal for Popular Prakashan Pvt. Ltd.
35C Tardeo Road, Bombay 400 034

The late Prof. D. D. Kosambi was a remarkable man indeed. He was a distinguished scientist who made outstanding contributions in various fields. He extended and enriched scientific methodology by applying it to the problems of archæology, history and culture and made original and far-reaching contributions in these fields. He is a unique example of combination of science, classical learning and scholarship. In his approach and outlook he represented a synthesis of the spirit of science and humanism.

Prof. Kosambi was not an ivory tower scientist, but an active participant in the national movement. The latter, he enriched through his writings, particularly with regard to the utilisation of science and technology for economic, social and cultural problems, by imbuing his students with a social perspective and by his active participation, particularly in the promotion of peace.

As a person he was sensitive, kind, affectionate and generous, and influenced a large number of young workers in the diverse fields of his interests. The large number of contributions received from all over the world for the commemoration volume is by itself an index of the esteem in which Prof. Kosambi was held and the international nature of his contribution in the diverse fields of knowledge.

In honouring Prof. Kosambi we are honouring one of our finest intellectuals and the best of the traditions of the country.

Rashtrapati Bhavan
New Delhi 4
May 28, 1970

V. V. GIRI

Preface

The news of the sudden death of the late Professor D. D. Kosambi at Poona on June 29, 1966 was received by his friends and admirers all over the world with painful shock and a deep sense of abiding loss. The idea of commemorating in a deserving manner his life and work was mooted at a condolence meeting held on the 9th July 1966 at the Fergusson College, presided over by the Vice-Chancellor of the University of Poona, Professor D. R. Gadgil. It was followed by another meeting of some of Prof. Kosambi's erstwhile colleagues and associates for considering various schemes to preserve his memory, amongst which the publication of a Commemoration Volume was found to be the most suitable for early implementation. Soon thereafter a Committee called the "D. D. Kosambi Commemoration Committee", with its headquarters at the Maharashtra Association for the Cultivation of Science, Poona, was organized. The first meeting of this Committee, presided over by Shri V. V. Giri, now the President of the Indian Republic, was held at New Delhi on March 14, 1968 for finalising the proposals.

There was an enthusiastic response to the appeal for contributions to the Volume, made by the Secretary of the Committee, to a select number of scholars known to be interested in Kosambi and his work in the various fields of knowledge. In view of the meagre resources at the disposal of the Committee, however, especially at the initial stage, it was decided to limit the extent of the Volume to within 300 pages. It was understood that a similar Commemoration Volume but devoted almost exclusively to the study of Indian social structure was being planned by a distinguished friend of Prof. Kosambi, viz., Prof. R. S. Sharma, Head of the Department of History, University of Patna. The possibility of having a joint publication of the two Volumes was explored but this was found both impracticable and unnecessary.

The present Volume is divided into three broad Sections, viz.,

(1) Articles in Humanities, (2) Articles in Science, and (3) Reminiscences of Prof. D. D. Kosambi and his views. The task of selecting and editing the material on such a wide variety of topics, presented in different styles of writing, and fitting it within the prescribed limits was by no means easy. Howsoever unwillingly, the sub-committee appointed for editing the Volume had not only to eliminate repetitions, and reduce some contributions to mere extracts but even to omit some of them in order to maintain a certain amount of balance and proportion in the presentation of the material. For this kind of liberty the editors have relied upon the kind indulgence of all our collaborators, bound as we all are by the common tie of friendship and sincere appreciation of the work of the gifted personality to whose memory the Volume has been dedicated.

The list of Contents will testify to the varied fare offered in the different Sections of this Volume. We will not attempt here even a brief survey of it; however special mention deserves to be made of two important articles of a general nature, penned by Prof. Kosambi himself, which have been included herein, viz., 1. "Combined Methods of Indology" (already published in the *Indo-Iranian Journal*, Vol. VI (1963), No. 3/4, pp. 177-202) in the Humanities Section, and 2. "Steps in Science", which is being published here for the first time as coming under the Science Section. Both of them illustrate the methodological approach and style of Prof. Kosambi. The latter article is particularly noteworthy for its autobiographical content, which gives us a glimpse of the progressive involvement of Kosambi's mind into ever-widening fields of interest and the development of his characteristically far-reaching, penetrating and synthetic quality of thinking.

A major share of the credit for this publication goes to Bhatkals of the well-known Popular Prakashan, Bombay, who came forward to undertake the full responsibility of bringing out the Volume in its present excellent form. Without their generous gesture the Volume would not have seen the light of day.

Prof. D. D. Kosambi
Commemoration Committee

July 26, 1974

Professor Damodar Dharmanand Kosambi was a friend of the family, an avid book buyer and an author of whom we could justifiably be proud. We had the good fortune of rendering service to him for nearly three and half decades when he made Poona and Bombay his sphere of activity.

It was a proud privilege for us to publish *Introduction to the Study of Indian History* which undoubtedly along with *Myth and Reality* has given a new dimension to an area of thinking which is vital to the development of Indian intellectual life. During the time the two books were under production we spent many a moment full of discussion—animated dissent and meaningful suggestions—but ever so heart-warming and always enjoyable and enlightening.

We announced this publication as also the collection of his selected writings in 1970. There was a long period of delay in seeing the manuscript through the press due to various unforeseen and unavoidable difficulties—production technicalities and administrative problems. We deeply regret this delay. On account of technical problems of composing the mathematical work and articles involving diacritical marks, the publication was held up considerably. The publication, despite all efforts, does not have a few diacritical marks and thus is not free from minor slips for which we crave the indulgence of readers. The typesetting work was done with the cooperation of M/s. Komposetors and India Printing Works. Thanks are due to Shri V. P. Bhagwat of Mouj Printing Bureau for undertaking this arduous job.

It is also necessary to record that details about the contributors to this volume could not be updated in all cases. We are grateful to the Prof. D. D. Kosambi Commemoration Volume Committee for giving us this opportunity to undertake this publication and to Shri W. N. Bhat, a close friend of Prof. Kosambi who provided the expressive frontispiece photograph for this volume.

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Part I

**Essays in Humanities
including Indology**

1 Combined Methods in Indology

D. D. Kosambi

This note suggests that the linguistic study of problems of ancient Indian culture would be more fruitful if supplemented by intelligent use of archaeology, anthropology, sociology and a suitable historical perspective.¹ Available Indian data in each of the fields listed need to be augmented by a great deal of honest and competent field work. None of the various techniques can, by itself, lead to any valid conclusion about ancient India; combined operations are indispensable.

1. Preliminary

The main idea back of the suggestion is that people who live alike tend often to act and to think alike, especially if their historical development has followed parallel courses. Indian peasants in villages far from any city live in a manner closer to the days when the Purāṇas were written than do the descendants of the brahmins who wrote the Purāṇas. A stage further back are the pitiful fragments of tribal groups, usually sunk to the level of marginal castes; they rely heavily upon food-gathering and have the corresponding mentality. The existence of such differences is ignored by the Indian intelligentsia, to the detriment of its reasoning. In the judgment of Louis de la Vallée Poussin:² "Les savants de l'Inde sont excellents pour la lecture

¹The reader is referred to two works of mine, entitled: (a) *Introduction to the study of Indian History* (Bombay, 1956) and (b) *Myth and Reality; studies in the formation of Indian culture* (Bombay, 1962), where further references will be found. Facts about Mahārāṣṭrian villages or customs from my own observations in the field are not documented.

²L. de la Vallée Poussin, *Dynasties et Histoire de l'Inde depuis Kanishka jusqu'aux invasions musulmanes* (Paris, 1935), avant-propos, p. xix, footnote. Special attention is called to pp. 360-361 of this book, for important additional remarks on the process of brahmanisation.

des textes, l'étude des dates, etc. Mais quelques-uns sont bien les neveux des philosophes bouddhistes ou brahmanisants. A ceux-ci toute explication est bonne dès qu'elle est spécieuse, et ils jouent avec des abstractions du second degré comme avec des réalités concrètes". This criticism, unfortunately too true, applies not only to *Indian* savants. The brahmanising tendency has seriously affected many distinguished foreign scholars whose long and exclusive concentration upon brahmin documents seems to have impaired their ability to distinguish between myth and reality.

One consequence of such neglect may be seen in the formulation of "Hindu" Law. This type of jurisprudence is mainly brahmin traditional usage on property rights and inheritance. The *smṛti* injunction (Ms. 8.41) that judicial (*dharma*) decisions were to be given only after due consideration of the particular law and the usage of the region, caste-group and family group, guild etc., was apparently followed for a long time.³ However, no written record exists of any cases tried under this heterogeneous system. No attempt was made even by the British to study and collate the various caste-laws carefully as a preliminary for Indian common law. New forms of property were regulated under the foreign (British bourgeois) law; crime by an arbitrary penal code. The caste *sabhās* continue to function off the record, with diminishing force and powers. When the question of Hindu widow remarriage was being violently argued by reformers at the beginning of this century, even the most scholarly (like R. G. Bhāṇḍārkar) looked only to correct interpretation of the sacred texts, from the *Ṛgveda* down. That 85% of the population in their immediate locality allowed widows to remarry (and permitted divorce when either party felt aggrieved) made no impression upon the scholars nor upon the authorities on Hindu Law. P. V. Kāṇe's monumental history⁴ of the *Dharmaśāstra* meticulously restricts the discussion to *smṛti* documents, avoiding any disagreeable contact with anthropology, sociology, or reality. This tunnel vision persists in all disciplines concerned with Indology.

³ The *Kṛtyakalpataru* of Bhaṭṭa Lakṣmīdhara (a minister of king Govindacandra Gāhaḍavāla of Kanauj); Gaekwar Oriental Series CXIX for vol. 12 of the work, being the *vyavahāra-kāṇḍa*. No special *praetor peregrinus* existed, and no *ius gentium* seems ever to have been officially recorded or codified, though its existence in practice is clear.

⁴ P. V. Kāṇe, *A History of Dharmaśāstra (Ancient and mediaeval religious and civil law)*, 5 volumes (still incomplete), Poona, 1930-1962. Though the vast majority of India's people are *śūdras* in this classification, there is no way to determine just what *śūdras* were actually meant by the few authors who wrote on *śūdra* rites and legal usage.

Field work has one disadvantage for arm-chair linguists. The amazing deftness with which world-shaking conclusions can be drawn without moving out of the study becomes less serviceable. I was told by a good linguist that the rather unusual Marāṭhī village name of Gomāśī (gad-fly or cattle-fly) has its obvious etymology. The villagers, however, usually speak of the place as *goam*, shortened from *go-ama*. The actual spot so designated is a small cave near the village with a fine 6th century image of Buddha, also unique for the region. Gotama Buddha had become Gotama *ṛṣi* for local brahmins and the villagers follow the Prakrit form *goama* (+*isi*). Gomāśī can thus be traced step by step to *gotama*—*ṛṣi*, though the derivation at one jump seems to contradict accepted rules. The village name Pāsaṇe is pronounced in half a dozen different ways within a range of twenty miles. The last syllable can vary, as in peasant Marāṭhī, from *na* to *ne*, while the *sa* becomes a cerebral *ca* or the dental *ta*, for reasons that could not be discovered. Learned theses on Marathi continue to be written as if such difference did not exist; as if the rustic speech of Sātārā district were not markedly different from that of the adjoining Konkan. In Goa it was possible in 1925 for a keen ear to emulate Bernard Shaw's Pygmalion-Higgins and to locate a person's origin within five miles merely by his or her speech, which also gives away the speaker's caste or religion, status, profession and educational accomplishments to an observer who knows the locality.

This diversity raises a natural question about the language of Asokan edicts. The local varieties have been determined by philological analysis;⁵ the text of the same edict is not absolutely identical in different localities. This caused T. W. Rhys Davids⁶ to declare that: "The Buddha and his followers adopted . . . the particular form of this common speech . . . that was current in Avanti". Does the Pāli canon represent the idiom actually in the Buddha's mouth, through a collection made from oral tradition some two centuries after his death? The Buddha's strict injunction to his disciples to preach in the languages of the common people is either ignored or taken to mean that the said languages differed by no more than the various versions of the same edict. The discovery of the Shar-i-Kuna⁷ (Kandahār) edict in Greek and Aramaic (without a Māgadhī equivalent), a brief

⁵ E. Hultzsch, *Corpus Inscriptionum Indicarum* I (The inscriptions of Asoka), Oxford, 1925 gives the complete Asokan texts known to that date, and a linguistic analysis.

⁶ *The Cambridge History of India*, vol. I, *Ancient India*, ed. E. J. Rapson (Cambridge, 1922), p. 187.

⁷ First published in full in *Serie Orientale Roma* (ISMEO) XXI, 1958:

résumé of the standard Asokan declarations, changes the picture. It is difficult to believe that Greek and Aramaic were then the two languages of Afghanistan, though they were undoubtedly the two major languages and scripts which would reach the great majority of literate people passing through Kandahār. Asokan Prakrit and Brāhmī have to be given the same position in the greater part of India, a country where the language must then have changed from one small valley to the next as it does in Assam today. The decrees were promulgated by the emperor, but the rescripts circulated by his predominantly Magadhan secretariat. It is not plausible that spoken Māgadhi had then so little inner variation as the pillar and rock texts show. During a walk of twenty miles in Goa, “want to go” changes from *jāumka hoyo* to *vacūmka jāya*, while another twenty miles in the same direction reduces it to *vacakā*; this is for peasants of the same caste and status who manage nevertheless to understand each other. Patañjali⁸ gives local usage in spoken Sanskrit (not different languages) of his day: “goes” was *śavati* in Kamboja, *hammati* in Surāstra, *ramhati* in the east (the Gangetic regions), but *gamati* for “real Aryans”. Yet Sanskrit then possessed the standardization of an extensive literature, the scriptures being committed to memory without alterations of a single syllable or accent. In both cases, the reported variation is much greater than for the official Prakrit of Asoka. The analysis of the latter cannot therefore be put upon the same footing as the comparison of early Greek epigraphs, say Ionian, Attic, Doric and Cretan linear B. These were issued by independent local authorities in a land where the profusion of written contracts and registers afforded a striking contrast with India—where the natives’ honesty and truthfulness in the absence of written agreements astounded Greek observers.⁹ The Prakrit spoken by different characters in the *Mṛcchakaṭika* has been separated into varieties labelled with local names. But even the *Mṛcchakaṭika* Caṇḍālas use a Prakrit easily understood by the rest, while the Caṇḍālas of the Jātakas spoke a language among themselves incomprehensible to “Aryans”. The parallel is with the idioms used by a Welsh or Irish character in a modern English play as against

Un editto bilinguale Greco-Aramaico di Asoka. The treatment in JA, 1958.1-48 seems preferable.

⁸ Commenting on the *vārtikā*: *sarve deśāntare*: p. 65 of Patañjali’s *Vyākaraṇa Mahābhāṣya* with Kaiyaṭa’s *Pradīpa* and Nāgeśa’s *Uddyota*, vol. I, Nirnayasaṅgar Press, Bombay, 1938.

⁹ The original remark may have been by Megasthenes, and is seen in its most forceful version in Arrian’s “No Indian is ever known to lie”.

the actual Welsh language or Erse. Though the variation is decidedly less than one would expect from Patañjali, the use of Prakrit is more natural in this particular drama than in other Sanskrit plays. Here, the Sūtradhāra declaims in Sanskrit to the audience, but lapses into Prakrit with his own womenfolk; much as educated Goans who consider Portuguese of Marāṭhī to be their real language speak Koṅkaṇī to women and servants. No other Sanskrit drama makes so great a concession to everyday life, just as none other deals with a historical in preference to a mythical episode. Literary Prakrit with all its varieties had become standardized, five centuries after Asoka. The presumption is strong that the observed variation in Asokan Prakrit is due to clerks and officials of the secretariat rather than to common local usage; very few of the original inhabitants of Maski in Mysore could have mastered the Magadhan tongue.

In modern science, it has been recognized that the variation is a very important characteristic of the material, particularly when dealing with living organisms. Fundamental methods developed by R. A. Fisher¹⁰ and others for taking such variation into mathematical account have led to great advances in biology. But I have yet to see any recognition of the philosophical principle, let alone the use of delicate statistical tests, in Indology. Still worse, most of our field work is done by educated men who often miss significant features or impose their own views upon the observed. In particular, the world of the women with its secret rites exclusively the property of female members of the group and the inevitable archaisms that mark the speech of the women when trade and intercourse with strangers is a male prerogative—all these inevitably escape observation, especially when the ritual has not been written down and the language not standardized by formal education.

2. *Ibhya*

India is a country of long survivals. It is known that the Buddha’s birthplace was the sacred grove of a Mother-goddess still worshipped at the spot under the same name after two and half millennia; but the Śākyas and Buddhism have vanished from the locality. Literate Mahārāṣṭrians use the word *leṇe* (= *layanam*) for a monastic cave, originally excavated as a retreat, and referred to in Sātavāhana inscriptions under essentially the same name. To the peasantry near Kārle caves the natural term is *veher* (often pronounced *vyahar*), from the Buddhist *vihāra*, which the caves actually were for centuries. Surprisingly enough,

¹⁰ R. A. Fisher, *Statistical Methods For Research Workers*; 10th ed. (Edinburgh, 1948).

the term changes at Karhād (the ancient Karahāṭaka) where the (6th century A.D.) Buddhist caves are called *vavri*, an archaic Sanskrit word whose filtering down to the lowest stratum of the population can only be explained by the strength of the brahmins at Karhād. The peasant dialect about Karhād is otherwise not more influenced by Sanskrit than elsewhere in Mahārāṣṭra. The caves were carved out by a class of people intimately connected with the brahmins of a great trade centre.

These survivals naturally lead to the view that there has been no real change in India over the ages. Among the more stupid displays may be mentioned A. A. Führer's publication¹¹ of a photograph of Tharu tribesmen near the Buddha's birthplace as modern Śākya, though there was nothing whatever in the tribal name or legends to indicate the equivalence. Fa-hsien's account¹² showed that by the 4th century A.D., the Śākyan capital was virtually deserted. By the time of Hsüan Tsang in the early 7th century, a Buddhist revival seems actually to have relocated Kapilavastu several miles away from its original site,¹³ if the two travellers' accounts (so accurate in detail) are to be reconciled. How many tribes (before the Tharus) wandered over the Śākyan *janapada* remains unknown. This "timeless unchanging East" theory may insidiously distort the entire meaning of a document and thus reduce the value of our already meagre source material. For example:

Rgveda 1.65.7 describes the fire-god Agni: *ibhyān ná rājā vānāny atti* "As a king the *ibhyas*, so eats he (Agni) up the forests". K. F. Geldner¹⁴ translates this as "Wie der König die Reichen frisst er die Hölzer auf". The footnote to this gives an

¹¹ A. A. Führer, *Buddha Śākyamuni's Birthplace in the Nepalese Tarai* (Allahabad, 1897).

¹² A Record of the Buddhist Countries by Fa-hsien; Peking 1957. The translation in S. Beal's collection: *Ta-Tang-Si-Yu-Ki: Buddhist Records of the Western World*; 2 vols., London, 1884, also contains this in the introductory portion.

¹³ The discrepancy seems to have been first considered in achaeological detail by Vincent Smith in the prefatory note (p. 10) to P. C. Mukerji's "A report on a tour of exploration of the *Antiquities in the Tarai, Nepal*, the region of Kapilavastu during February and March 1899" (Arch. Surv. Ind. No. XXVI, pt. i, Imperial Series; Calcutta 1901). Smith was capable of identifying Satna railway station in central India with the site of ancient Kauśāmbi (JRAS, 1898, 511), but his discussion of the Kapilavastu problem seems reasonable. The strictures on pp. 3-4 of the same preface about Führer's supposed excavations are by no means excessive.

¹⁴ K. F. Geldner, *Der Rig-Veda aus dem Sanskrit ins Deutsche übersetzt und mit einem laufenden Kommentar versehen*. Cambridge, Mass. (Harvard Oriental Series, vols. 33-35) 1951. For the Sanskrit text and Sāyaṇa's commentary, I have used the 4-volume edition of the

alternative: "Oder: Wie ein König seine Vasallen". Sāyaṇa commenting on the same *ṛk* gives *ibhyā śatravaḥ . . . yad vā dhaninaḥ; tān yathā dhanam apaharan rājā hinasti tadvat*. Thus, Geldner has taken the second of Sāyaṇa's alternatives for a word that occurs just once in the whole of the *Rgveda*. That this did not entirely satisfy seems clear from his note on RV. 9.57.3 *ibho rājēva suvratāḥ*. The footnote here reads: "Die Verbindung von *ibha*, *ibhya* mit *rājan* 1.65.7; 4.4.1 und hier) ist für beide Wörter bedeutsam und harrt noch der sicheren Lösung. Andererseits ist die Bedeutung "Elefant" für *ibha*, "reich" für *ibhya* durch das spätere Sanskrit (*rājā ibhena* Manu 8.34!) so gesichert, dass sie kaum zu umgehen ist. *ibhya* wird sich zu *ibha* verhalten wie *dhānya* zu *dhāna*. Pāli *ibbha* in der bekannten Formel (s.P.D.) und *ibha* in Chānd. Up. 1.10.1-2 sind aus dem Zusammenhang nicht mehr sicher zu bestimmen . . . Lehnt man aber die klassische Bedeutung für den Veda ab und sucht den Sinn in der von Roth gewiesenen Richtung, so empfiehlt sich statt "Gesinde, Hörige" (Roth) vielmehr für *ibha* und *ibhya* "Vasall". *ibho rājā* wäre dann der Vasallenkönig".

This is a valiant attempt made by a scholar of merit to settle the meaning of a unique term in a document which he had studied intensively for so many years. The basic question is whether *Rgvedic* society had kings who ruled absolutely over vassals and over elephant-owning noblemen. It would seem extremely unlikely, taking the hymns as a whole. On the other hand, if the meanings of *ibhya* could be more closely determined, a certain amount of history emerges from the verse in question. The matter could have been settled by Asoka's 5th Rock Edict which is clearly legible for the relevant portion at Dhauli, Shahbazgarhi, Kalsi and Mansehra. There, *bambhanibhesu* is beyond question an antithetic compound, like the preceding, "masters and servants". One should expect that the *ibbha* here would be the lowest of castes, as the brahmin was the highest. However, the point may still be argued, and Jules Bloch,¹⁵ for example, deliberately leaves the word untranslated, as he does every other

Rgveda-Samihitā issued by the Vaidik Samshodhan Maṇḍal, Poona, 1933-1946.

There may have been a sort of feudalism at a stage not much later than the *Rgveda*, among the Hittites: E. Neufeld; *The Hittite Laws translated into English and Hebrew with commentary* (London, 1951), particularly laws 39-41; 46-56 for military service as condition of land tenure. But there is no evidence for comparable fixed land settlement in the *Rgveda*, nor for a king ruling over many different tribes by the military strength of a few of his own tribal comrades, as with the Hittites.

¹⁵ J. Bloch, *Les Inscriptions d'Asoka* (Paris, 1950), p. 104.

word that might contradict the idea that Asoka was a pious dotard bent upon preaching Buddhism. So, we might look closer at the two sources which seemed indecisive to Geldner.

The *Pali Dictionary*¹⁶ of Rhys Davids gives *ibbha* primarily as the lowest of menials, lowest of the low. The context of the third *sutta* of the *Dīghanikāya*¹⁷ (*Ambaṭṭhasutta*) makes it certain that *ibbha* is used as a term of abuse, to indicate the contempt in which some local brahmins held the Sakyans as men of low lineage. This meaning fits all contexts cited, and is generally accepted. The only other meaning given by that dictionary is late, in a comment of Buddhaghosa on the *Jātakas*. As for the Chāndogya Upaniṣad reference, there seems to me no doubt of the meaning of *ibhya* in its particular context. The story is of a brahmin Uśasti Cākṛāyaṇa of the Kuru country, who was wiped out by a plague of locusts (*maṭacī-hata*; commentators prefer "hailstorm"). At a village of *ibhyas*, he saw an *ibhya* eating *kulmāṣa* broth, begged the leavings (which his wife could not bring herself to eat, famished as she was) and from the strength gained from this distressing meal, made a success the next day at the royal sacrifice. The commentary that passes under the name of Śamkara gives for *ibhya* the alternatives "rich man" or "elephant-driver (of low caste)"; whereof Hume in his English translation takes the first. Gopālānanda-svāmi¹⁸ in his comment gives only *hastipak* = elephant-driver for *ibhya*. Geldner may seem to appear justified in his assertion of ambiguity. But what is *kulmāṣa*? Neither lexicists nor commentators make of this anything but food of the lowest grade. Whether my personal interpretation of *kulmāṣa* as the lowly vetch *Glycine tomentosa* is accepted or not, it was certainly not food for a nobleman rich enough to own elephants. The story has a point only if it shows the desperate straits to which a learned brahmin had been reduced. Not for the first time in our records, for Vāmadeva in RV. 4.18.13 claims to have cooked a dog's entrails in hunger: *āvartyā śūna āntrāṇi pece*. This *ṛk* is put into Indra's mouth by Geldner, who here ignores the logically consistent brahmin tradition reported by Sāyaṇa and by the Manusmṛti (10.106) to the effect that the degradation was

Vāmadeva's.

Finally, what can a village of *ibhyas* (where an *ibhya* could be seen eating outdoors) mean, if not some hamlet inhabited by people of a low caste-guild? Such villages still exist. If you take *ibhya* as the equivalent of the tribal caste Mātaṅga, the modern *māṅg*, originating from people with an elephant totem, every one of the passages discussed makes sense. The Aryan king of RV.1.65.7 would eat up tribal savages mercilessly. The brahmin could take soiled food from the lowest caste only in times of unutterable famine.

3. *Sāmanta*

Naturally, this raises the question of feudalism in India: When did vassals and feudal barons as such come into existence? The Sanskrit word to be discussed is the post-vedic *sāmanta*, meaning originally "neighbour" or "neighbouring ruler". In his indispensable translation of the *Arthaśāstra*¹⁹, J. J. Meyer generally takes this in its later meaning 'vassal'. If the translation is justified, then India was unique in having a feudal system about a thousand years before Europe, or the document is a late forgery. But no one puts the book later²⁰ than 300 A.D., and the question must be asked whether feudal barons were in existence even at that period. The *Jātakas* show *sāmanta* only as "neighbour"; the feudal institution is absent. The few *kṣatrapas* and *mahā-kṣatrapas* known in inscriptions are actually or virtually independent kings. Fortunately, it is possible to date, within limits unusually narrow for India, the period when *sāmanta* acquired the meaning "feudal baron".

We may note that even in the *Arthaśāstra*, the word *sāmanta* has often the meaning "neighbour", without alternative — as for example in Arth. 3.9 when transfer of title to houses and plots of land is in question. However, in every single case, *sāmanta* can consistently be translated as neighbour, whether royal or commoner, without incompatibility. In fact, in Arth. 6.1., Meyer contradicts himself by translating *śakyasāmantaḥ* at the beginning as "Herr über seine Vasallen" and in the middle of the same chapter as "von Grenznachbarn umgeben, die man in der Gewalt hat". The latter translation would fit both contexts, the former would not. There is no *sāmanta* baron in the Manusmṛti.

¹⁶ The Pali Text Society's *Pali-English Dictionary*; London, 1921.

¹⁷ The Pali Text Society's edition of the *Dīghanikāya*, vol. I (London, 1890), p. 90; Buddhaghosa comments: *ibbhā ti gahapatikā* (peasants), on p. 234 of the *Sumaṅgala Vilāsinī*, vol. I (London, PTS 1886).

¹⁸ The Nirṇayasāgar editions of the Upaniṣads have been used for the text. With the commentary of Gopālānanda-svāmi, NSP 1932. For the English translation, R. H. Hume, *The thirteen principal Upaniṣads translated from the Sanskrit* (Oxford, 1934).

¹⁹ J. J. Meyer, *Das altindische Buch vom welt- und Staatsleben; Das Arthaśāstra des Kauṭilya* (Leipzig, 1926); the text used has been the revised southern edition *Kauṭilyārthaśāstram* (Mysore, 1960).

²⁰ A. Berriedale Keith, *A History of Sanskrit Literature* (Oxford 1928), p. 461. The discussion in my history book (note 1) and in JAOS 78.169-173 may be referred to for the authenticity of the *Arthaśāstra*.

The earlier Guptas rule over no *sāmantas* in their inscriptions; the posthumous Hariṣeṇa *praśasti*²¹ of Samudragupta on the Allahabad pillar mentions no barons. Dharasena of Valabhi who appears as the first *mahāsāmanta*²² in A.D. 527 is an independent king friendly to the Guptas (from the tone of his inscriptions), not a peer of the realm. The Mandasor pillar²³ inscriptions of Yaśodharman, who drove Mihiragula and the Huns out of Mālwa, say that the king defeated and humbled all the *sāmantas*, which can only mean neighbour kings. But the Viṣṇuśeṇa charter²⁴ of 592 A.D. takes *sāmanta* only in the sense of petty feudal viscounts who might press labour for corvée, or infringe upon the rights and immunities of merchants to whom the charter was granted. Thus, the change in meaning falls within a period of less than 60 years, say the second half of the 6th century A.D. It is confirmed by the Ten Princes²⁵ of Daṇḍin, where *sāmanta* can only mean feudal baron, though the author shows remarkably close reading of the Arthaśāstra as of many other works. The copper plates²⁶ of Harṣa, supported by Chinese travellers' accounts, prove that feudal relationships and *sāmanta* "baron" had come to stay.

²¹ J. F. Fleet, *Inscriptions of the early Gupta Kings and their successors*; *Corpus Inscriptionum Indicarum III* (Calcutta, 1888). The Hariṣeṇa *praśasti* of Samudragupta (posthumous) is on pp. 6-17.

²² *Ibid.*, p. 41 of the introduction. As the founder of the Maitraka line was Bhaṭārka, a *senāpati*, the interpretation of *mahāsāmanta* as 'duke' would have been justified only if the Valabhi kings made any reference to some Gupta emperor as suzerain.

²³ *Ibid.*, inscription No. 33, pp. 146-8. Line 5 of the inscription has *sāmantair yasya bāhu-draviṇa-hṛta-madaih pādayor ānamadbhis*, but these *sāmantas* are explicitly mentioned as coming from territories over most of which Yaśodharman had set up no administration and could claim no permanent sovereignty, namely from the Himalaya to the oceans. The reference can only be to kings defeated in some passing raid or invasion, and this is strengthened by special mention in the preceding line of Huns (Mihiragula) and other kings, whom even the Guptas could not vanquish but who were beaten by Yaśodharman.

²⁴ D. D. Kosami, Indian feudal trade charters, *JESHO* 2, 1959, 281-293.

²⁵ *Daśa-kumāra-caritam* of Daṇḍin, 14th ed. by N. K. Goḍbole, Nirṇayasāgar Press (Bombay 1940), p. 184; but the remarkably silly comment *sāmantah syād adhīśvarah* made by lifting half a phrase out of the *Amarakośa* confuses the issue. The context here, as in chapter 8 (p. 267 ff.) does not leave the meaning in doubt. Keith (*Hist. Skt. Lit.*, p. 297) suggests a date slightly before Harṣavardhana for Daṇḍin, so towards the end of the 6th or beginning of the 7th century A.D.

²⁶ *Epigraphia Indica* 4.208-211, where *mahāsāmantas* are named for the execution of the Banskhera plates of Harṣa. See also p. 130 of Bāṇa's *Harṣacaritam* (7th ed. NSP Bombay, 1946), where only 'baron' will suit; on p. 100, 150 &c., *mahāsāmantas* of the court are named again.

The entire structure of the Arthaśāstra, considered as a whole, contradicts the possibility of feudalism. The state collected its taxes in kind, but processed and made into commodities an enormous number of natural products thus gathered. The whole economy and the system of administration was based upon cash valuation, as may be seen by the minutely detailed table of fines and of salaries. Moreover, the state itself owned most of the land under the title of *śītā*, the *rāṣṭra* being still under private enterprise of various sorts though subject to imperial taxes. Neither in the mechanism of collecting taxes, nor in the administration of law and order, nor in military service is the *sāmanta* feudal officer mentioned; the respective officials are named, and have fixed monthly salaries paid in cash. The high ministerial *mantrin* and *amātya* are also salaried posts not based upon hereditary tenure or nobility of rank. A "vassal" in the feudal sense would make the whole document logically inconsistent. As for the neighbouring rulers, the whole purpose of the Arthaśāstra is to make its kin the universal monarch, starting on level terms with the *sāmantas*. Bpt conquest did not mean reduction of the beaten king to vassalage; he and his officials were to be maintained in their old position. No special tribute is mentioned. The profit of aggression came to the conqueror from the development of waste land as new *śītā* plus absolute control of mineral resources as a state monopoly. The land visualised is one divided into *janapada* territories, each originally belonging to a particular tribe, say Magadha, Kosala, Videha, etc. These were separated by extensive forests infested by predatory *ātavika* savages who were still in the food-gathering stage, difficult to conquer by military methods, or at least to conquer with due profit. In the intermediate stage were a few powerful, armed, tribal oligarchies. These had to be broken ruthlessly by every method at the king's command. There was no need or place for feudalism in any recognizable meaning of the word, in this type of state.

Not only do these considerations furnish important data for Indian history, but they also help clarify points that remain unexplained or have escaped attention. The Allahabad *praśasti* of Samudragupta²¹ says that he had reduced all forest kings to servitude: *paricārīkī-kṛta-sarvātavika-rājasya*, and the context shows that this refers to Āryāvarta, the Gangetic basin, probably including West Bengal. This finished the course of settlement begun by Magadhan kings before the Arthaśāstra, and accounts for the new prosperity of the Gupta empire. The great forest still existed in places, e.g. between Allahabad and Banāras, but had been cleared of armed savages; its reduction to farmland

was a matter of time, no longer of armed intervention. Gupta gold coinage, beautiful as it is, supplements Chinese pilgrims' accounts to show that barter economy was becoming prevalent; Harṣa's coins are so few that the economic trend seems to have been virtually complete by the 7th century A.D. Other steps to feudalism were payment of officials by the income of specially assigned plots of land—impossible in the Ṛgvedic economy (when fixed plots did not exist) and frowned upon by the Arthaśāstra. The definition of the paramount ruler: *rājā tu prajāpāṇiśa-sāmantaḥ syād adhiśvaraḥ* in Amarakośa 2.8.2. fits only the Yaśodharman type of conqueror of neighbouring kings; *sāmanta* as "feudal baron" would not explain the given hierarchical order: *adhiśvara*, *cakravartin*, *sārvabhauma*; but if none of these, then a *maṇḍaleśvara*. It follows that the Amarakośa cannot be later²⁷ than the first half of the 6th century A.D. The tradition that places its writer at the same court as Kālidāsa seems quite reasonable so that the work may be as early as the late 4th century A.D. On the other hand, I had placed the poet Bhartṛhari in the opening centuries of the Christian era, which can be disproved on our deductions about the meaning of *sāmanta*. The Bhartṛhari stanza²⁸ that begins *bhrātaḥ kaṣṭam aho* (or *sā ramyā nagarī* in the southern recension) takes *sāmanta* as the high noble of a royal court, and is attested by all complete MSS. Inasmuch as the manuscript evidence also compels inclusion of the stanza *bhavanti namrās taravaḥ phalodgamaiḥ* which is to be found in the Śākuntalam²⁹ of Kālidāsa (whereof the critical study needs to be extended), it follows that even the nucleus of the Bhartṛhari collection contains verses composed two centuries or more apart; the archetype restored on present MS evidence still remains an anthology.

To round out the discussion, it can be shown that the transition from the Ṛgvedic to the Arthaśāstra society as we have reconstructed it was natural. The relevant documents are the various *brāhmaṇas*, from whose diffuse liturgical contents a useful collection of data has been boiled down by W. Rau.³⁰ The

king of this intermediate period was a small princeling, without very rich elephant-owning *ibhya* vassals. As the first among equals, he could be deposed. The move towards absolute rule unrestricted by tribal law was also evident. The ostracized (*aparuddha*) king appears again to intrigue in a somewhat more ambitious role in the Arthaśāstra. Production on the land was, in each locality, in the hands of people with bonds of kinship, *sajāta*; this was the only form of association permitted on the Arthaśāstra ruler's *sītā* crown lands, and the text has been emended to *sujāta* (high-born, upper-caste) by heedless editors. The correct reading is confirmed by the fact that even under the Mughals, villages were generally tilled by a *birādarī* (kinship group), and undisturbed villages (e.g. in Mahārāṣṭra) are still populated by people with the same clan-name, usually reminiscent of some totem (e.g. Magar, Lāṇḍage, Vājī, More). While better developed than in the RV, the Yajurveda-Brāhmaṇa *grāma* was still a mobile association of human beings, who moved seasonally with their cattle to and from one territory to the other; very different indeed from the fixed agricultural village of today. The meeting of two such groups on the transhumance march meant conflict, as the word *samgrāma* for battle proves. If, now, we take Geldner's meaning for *ibhya* and Meyer's for *sāmanta*, the Ṛgveda, the Brāhmaṇas and the Arthaśāstra fail to give a consistent picture of developing Indian society.

4. Udumbara

Jean Przyluski (JA. 208. 1926. 1-59) describing the Udumbaras as an ancient people of the Punjab, reached the conclusion: "On peut donc admettre que Udumbara, Odumbara, Kodumbara sont les variantes d'un même nom désignant un peuple austro-asiatique du Nord de l'Inde". The basic theory, again in Przyluski's words, seems to be as follows: "La répartition des populations de l'Inde avant Alexandre aurait été le résultat de trois invasions successives. D'abord les Austroasiates recouvrent en partie l'élément dravidien et ne laissent guère émerger que l'îlot brahmi au Nord et les masses du Dekhan au Sud. Puis les Aryens, descendus dans l'Inde par le Nord-Ouest, s'établissent progressivement dans les vallées moyennes de l'Indus, de la Yamunā, du Gange, et rayonnent autour de ces foyers de culture brahmanique. Plus tard enfin, les Bāhlika, venus de l'Iran oriental, s'infiltrèrent, marchands et aventuriers, chez les tribus austroasiatiques laissées à l'écart par les Brahmanes; en organisant de vastes confédérations comme celle des Śālva et en faisant circuler de l'Ouest à l'Est leurs caravanes, ils préparent la formation des futurs empires et assurent la liaison de l'Inde et de l'Occident".

²⁷ Keith (*Hist. Skt. Lit.*, p. 413) vaguely places him about 700 A.D., but without committing himself.

²⁸ *The Epigrams attributed to Bhartṛhari* (Singhī Jain Series No. 23, Bombay, 1948) is the critical edition where the stanza may be seen as No. 169.

²⁹ *Ibid.*, stanza 63. In the 12th Nirṇayasāgar edition of the *Abhiññāna-śākuntalam* (Bombay, 1948, ed. N. R. Ācārya), act 5, stanza 12; in Pischel's Harvard Or. Ser. edition, 5.13.

³⁰ Wilhelm Rau, *Staat und Gesellschaft im alten Indien* (Wiesbaden, 1957), particularly pp. 51-54.

These conclusions have caught on very well with a certain class of brahminising disciples, lovers of the "explication spécieuse" and "logique imperturbable". The Austro-asiatics are even credited³¹ with the Indus valley civilization and that of Sumer! Rather than plunge into the linguistic morass, it might be more profitable to analyse the technical details of the three supposed pre-Alexandrian invasions.

The British "invasion" of India reached maturity in approximately two centuries. Its ultimate cultural dominance and military success rested upon superior technique of production and a social form (the bourgeois) decidedly more efficient than feudalism. The Muslim invasion took six centuries to span comparable stages. The military technique is again well known while their developed feudalism was more efficient than the priest-ridden Indian system before them. In both cases, the success was out of all proportion to the actual number of invaders. There was no question of "submerging" the indigenous population, no matter how much Islam grew by conversion. So, Przyluski's three invasions prior to Alexander's ephemeral raid must have been much more powerful in numbers, not to speak of superiority in productive technique, military organization, and social form, relative to whatever existed in India at the time of each.

The case for the Aryans supports these contentions at first sight. The older view that an "Aryan tribe" or "race" is as ridiculous a combination of attribute and noun as a "brachycephalic grammar" need hardly be considered. Strabo talks of Aryans on the banks of the Indus in Alexander's day; Darius I claims in his grave inscription to be an Aryan of Aryan descent: *ariya, ariyaciça*. So we need hardly go into the etymology of

³¹ Sunīti Kumār Chatterji in *The Bhāratiya Itihāsa Samiti's History and Culture of the Indian People*, vol. I: *The Vedic Age*, chapter VIII, for the statement of the Austroasiatic hypothesis. On page 153: "We may admit the possibility of Sumerian and Austric being related, for we have to remember that the Proto-Australoids, who are supposed to have been the original speakers of Austric, were a very ancient offshoot of the Mediterranean race, and as such in their trek to India where they became specially characterized they may have left some of their tribes on the way, or some of their kinsmen might earlier have preceded them and had established themselves in Mesopotamia, to become the Sumerians who built up the basic culture of that part of the world. But even then it seems that India was the centre from which the Austric speech spread into the islands of the east and the Pacific; and the theory that there is actually an Austric Family of Languages in its two groups of Austronesian and Austro-Asiatic, as propounded by Pater W. Schmidt, may be said to hold the ground still." I can't even understand this, let alone admit it.

Haryana and Iran or speculate about the Germanic Aarii in Tacitus. Archaeologists tell us that Aryan technique³² as such does not mean any special type of pottery or tool; they picked up whatever suited them while smashing through the barriers of little atrophied peasant communities in Asia Minor. The military success of the first wave, dated³³ at about 1750 B.C., may be ascribed to the fast horse-chariot and a mobile food supply of good cattle. The second main wave at about the end³⁴ of the 2nd millennium B.C. added thereto the knowledge of iron, the first cheap metal that made the heavy plough and extensive agriculture possible.

This last point, of no importance to linguistic scholars, must be properly understood. In six African animal preserves,³⁵ the annual "production" of meat ranges from two tons to 34 tons per square kilometre. First class range land in Oklahoma yields 14 tons of beef per square kilometre annually; good Belgian meadowland runs to 45 tons. All this is with modern conservation and fire-arms. If the meat were to be procured by traps, pitfalls or bow and arrow, the actual yield would be much less; supplementing primitive weapons by bush fires would cause (and has elsewhere caused) great ecological changes which deplete the supply of game and therefore eventually the human population. Briefly, a change from hunting and food-gathering to a pastoral economy in suitable territory would support, say, eight times the population on the same land; plough farming could again multiply the number of people by at least as great a factor.

³² V. Gordon Childe, *The Aryans* (London, 1926). The work needs revision, but the basic idea seems uncontradicted by new finds.

³³ A. L. Oppenheim, *The Seafaring Merchants of Ur*, *JAOS* 74, 1954, 6-17, a review analysis of Vol. V of the texts from L. Wolley's excavations at Ur, by H. H. Figulla and W. J. Martin: *Letters and Documents of the Old-Babylonian period* (London 1953). The break (due to an Aryan invasion) came about 1750 B.C. if Meluhha be the Indus valley; though so competent a scholar as S. N. Kramer would take Tilmūn as Harappā, it seems clear that the usual identification with Bahrein must stand (*JAOS* 74. 1954. 179). W. Wüst, curiously enough, also placed the Aryan invasion of the Indus region as at about 1750 B.C. (*WZKM* 34. 1927, p. 190), but this is simply a guess from poor archaeological material, without a scientific method for estimating the time from linguistic sources alone.

³⁴ The two-wave theory was confirmed by personal discussion with Prof. S. P. Tolstov, in 1955. The mention of Iṣṭāśva (= Viśtāśpa?), Iṣṭara-śmi, and Suśravas (Husravah) in the RV seemed to me philological evidence for the second wave; the archaeological basis in India may be the two layers of the Harappan cemetery H. Prof. Tolstov also showed Indian type of faces in Kushan frescos (Note 39 below), and in a skull reconstruction.

³⁵ The data will be found in *New Scientist* No. 251, Sept. 7, 1961; p. 566.

Moreover, cattle-breeding and agriculture provide a regular food supply, where food-gathering is uncertain.

Only the Indus region and part of the Gujarāt loess area could have had any farming other than primitive slash-and-burn (Brandwirtschaft) or digging-stick cultivation before iron became plentiful. The river flowing through an alluvial desert in a tropical climate is of the utmost importance. That is why we find the first civilizations in Mesopotamia, on the Nile, the Indus; not on the Amazon nor the Mississippi. Next best would be a loess corridor, as in China and on the Danube. This explains why the Ganges and Yamuna, though eventually the main centres of brahmin culture, could not have had any significant settlements till iron became relatively plentiful—not before the 8th century B.C. The first “Aryan” settlements were in upper Punjab and along the Himalayan foothills. Banāras is perhaps the earliest of the riparian states. Rājgir owed its position to the great ore deposits which lay close and to the south-east. The control of ore sources rather than brahmin organization of vast confederacies explains why Magadha was the first “universal” empire in India. The “masses du Dekhan” did not exist. Though Paithān was the terminus of the *dakṣiṇāpatha* (southern) trade-route from Kosala, the Deccan plateau was not opened to extensive agricultural settlement till late in the 6th century B.C., and could earlier have provided neither hunting nor pasture comparable to the best northern territory. The coastal strip with its terrific rainfall and heavy forest was developed after Aśoka. The pre-Aryan invasions meant at most a relatively thin scattering of stone-age people, except for the Indus valley. Even here, the light plough or harrow and flood irrigation must have been the norm; the absence of good ploughs and of canal irrigation may be deduced from the low density of ancient urban ruins in Sind and the lower Punjab as compared to Iraq.

Any preponderance of Aryans in number could only have been due to their ability to colonize lands undeveloped before their time, particularly the wooded foothills of the upper Punjab and the Gangetic basin; not that they came to India in great numbers, but that they bred faster and had a higher expectation of life because of the improved and more regular food supply. Aryanization thereafter means primarily the progress of plough agriculture in fixed land holdings—with a new social organization to correspond. The only people that adopted this without the Aryan idiom are Dravidians, not Austro-asiatics. So far as I know, neither the primitive Australians nor those aborigines whose languages (e.g. Munda, Khmer, etc.) serve as source-material for the Austro-asiatic theory produced any striking inno-

vation in food production. Whatever they know of serious agriculture, metal work, pottery and handicrafts (except weaving baskets and fishing-nets) seems to have been learned after the “Aryan invasion”, so that they still remain nearer to the food-gathering stage than any other people in the East.

The Udumbara tree (*Ficus glomerata*) is native to India. Its sanctity, use of its wood for royal consecration thrones, and its edible fruit indicate that it was a totem tree. In fact, there is a historical Udumbara tribe on whose coins³⁶ a tree normally appears, presumably the *udumbara*. There still exist low-caste Udumbaras in Gujarāt and a few Udumbara brahmins as well. The great Sanskrit poet and dramatist Bhavabhūti was such an Udumbara brahmin.³⁷ This does not mean organization by the brahmins of a “vast confederation” but that brahmins were adopted into the tribes, or joined the tribal priesthood. This process continued down to the last century³⁸ and is in fact the principal method whereby successive developing groups of *āṭavika* savages were enrolled as endogamous castes into general Indian society—the formal aspect of “Aryanization”, even in Dravidian regions.

5. *Sakadani*

The classification of ancient Indian peoples on a slender linguistic basis into Aryan and non-Aryan or pre-Aryan groups often excludes the possibility of consistent statements about customs, manner of life, or ethnic affinities. The Brahui “island” in the north is explained on the basis of a pre-historic Dravidian population all over the country. Actually, there is no reason to treat it as other than a casual survival of unabsorbed trading settlers from the south in historic times. Tolstov’s excavations at Khorezm show unmistakable south Indian types in stucco relief depicting soldiers on garrison duty for the earlier Kuṣāṇas in Central Asia; the find is supported by anthropometry of the skulls dug up at the site. Alberūnī³⁹ refers to Kanarese soldiers

³⁶ For Udumbara coins, J. Allan’s *Catalogue of Coins in the British Museum, Ancient India* (London, 1936), pp. 122-123. The legend is Odumbara and the region the Beas valley of the Punjab.

³⁷ The *sūtradhāra* in the prologue to the drama *Mālatīmādhava* says that the poet belonged to a group of brahmins settled at Padmapuram in the south (*dakṣiṇāpathe*): *Taittirīyāh Kāśyapāh; Udumbara-nāmānāh*.

³⁸ The most recent example known to me is of the Tigalās, whose tribal fertility rite was given respectable ancestry by a brahmin during the second half of the last century, and is now the most impressive popular festival at Bangalore.

³⁹ E. Sachau (trans.), *Alberūnī’s India*, 2 vol. (London, 1910); vol. 1, p. 173. For dark-skinned guardsmen at Toprak-kala (Tolstov’s excava-

in the armies of Mahmūd of Ghazni. Adventurers from the Dravidian section of the Peninsula had set up considerable factions at various courts, by the 11th century, even in Bengal.⁴⁰ Unless the existence of Brahui can be proved, say in the IIIrd millennium B.C. in about the same place as today, the linguistic explanation lacks force. The thesis becomes still less convincing when the Burushaski "island" on the Karakorum is taken into account. The assumption that the non-Aryan and non-Dravidian languages of India, all primitive tribal idioms, can be grouped together as having a common or similar "structure", whatever that term may mean, is doubtful.

Przyluski (*JRAS*, 1929. 273-279) derived Prakrit *sātakani* from *kon* "son" (Munda) and *sadom* "horse" (Santali, Mundari, etc.), as "son of the horse". He notes the horse emblem on certain Sātavāhana coins, then the Viṣṇuite-śaiva conflict and the flowering of Prakrit under a Śātakarṇi Hāla. The conclusion is: "Quand on voudra mesurer la part des influences anaryennes dans le développement de la littérature prakrite, on ne devra pas perdre de vue que l'onomastique des Andhras contient un important élément austro-asiatique".

This slipping off into a groove spoils an otherwise valuable study. There is no question that the Sātavāhanas rose from low tribal origins.⁴¹ Their region, as has been explained, had no agriculture to speak of before the 6th century B.C., hence could not have supported anything beyond small tribes with petty

tions) in the 3rd century A.D., see A. Mongait, *Archaeology in the USSR* (Moscow, 1959), p. 272. The wide extent of the Kushan empire not only made it possible to bring in soldiers from great distance, but even attracted mercenaries from beyond the imperial frontiers.

⁴⁰ The Senas who superseded the Pālas in Bengal were apparently of southern origin; Gaṅgeyadeva of Tirabhukti seems to have had Kanarese ancestors; some Pāla queens and princes are named in Kanarese style, and the final stanzas of the drama Caṇḍa-kaūsika imply that the wives of the Nandas were practised at the Gurjara-Pratihāra court by Kanarese nobles (cf. the introduction to the *Subhāṣitaratna koṣa* of Vidyākara, HOS, vol. 41, Cambridge, Mass. 1957).

⁴¹ The low tribal origin of the Sātavāhanas is preserved in Jain tradition, e.g. Rājasekhara-sūri's *Prabandhakoṣa* (ed. Jina Vijaya, Śāntiniketan 1935; Singhi Jain Series 6), story 15. The original Sātavāhana was born of a brahmin widow ravished and impregnated by the *nāga* (cobra-demon) of a pool in the Godāvarī river; Paithan was then a hamlet, and the widow's two brothers lived there by some sort of food-gathering. Tāranātha (in A. Schiefner's translation) similarly reports a *nāga* father for the first Pāla king. With the Mbh heroes, of course, we have the immaculate conception in the manner of Trobriand islanders, which means that the father was traditionally unknown, fatherhood then being of no importance; the Mbh tradition must basically have been pre-patriarchal, hence pre-Aryan.

chieftains; certainly not an "Aryan" king. The horse introduced by Spaniards in America ran wild, bred in large numbers, and was then used by Amerinds of the prairies, who thereby became more efficient in killing the bison. The Aryan horse would similarly have reached some aborigines in the Deccan, or been acquired from northern caravan merchants by way of trade. The tribe or family groups who first used horses would gain superiority in warfare and the hunt. Sātakani would be equivalent with "horse totem", which agrees with Przyluski's findings; but the Austro-asiatics are superfluous, inasmuch as the totem is found with the horse all around the old world, from the White Horse of the Saxons to the clan name Ma among the Chinese.

The development into Śātakarṇi and Sātavāhana is of peculiar interest. The name is apparently a direct Sanskritization of *sātakani* by late writers in possession of extensive and beautiful Prakrit literature, but ignorant of the actual dynasty whose tribal origins had vanished into dim antiquity. The *Kalki* (*anubhāgavata*) *Purāna*⁴² reports a *Saptivāhana* king named Śaśidhvaja, who gave his daughter to Kalki. That Kalki was a minor historical character later promoted to a messianic future *avatāra* is clear from all extant narratives; he was the son of a brahmin and a woman of the low Mātāṅga caste (our *ibhyas* again) and his symbol is the white stallion. Sapti is good vedic Sanskrit for horse, with special reference to the sacred horses of the sun-god's chariot. Both *sapti* and *saptan* "seven" could be prakritized as *sāta*; the natural confusion may account for the seven horses of Sūrya, who is called *sapta-sapti* and so depicted in many icons. The *vāhana* "vehicle" of an Indian deity is generally shown as his mount, but is obviously a totemic manifestation of the god or goddess. Thus Brahmā is the swan. Clear evidence of pre-historic and pre-Siva worship of the humped bull⁴³ has been uncovered by archaeologists. The large animal which normally occupies the greater part of an Indus seal is presumably a clan emblem, just as the Athenian Boutadai had their shields marked with a bull's head. There is a direct line of descent from the prehistoric ice-age artist's pebble "sketch-sheet" and the stamp seals and cylinder seals used to protect merchandise from Mesopotamia to the Indus.

Saptikarna "horse-ear" sounds like a "split totem" which sometimes develops when a primitive exogamous clan splits into

⁴² In the printed edition (without frontispiece, Bengali form of *devanāgarī* type) 8.1; the *Saptivāhana* is given as king of Bhallātanagara.

⁴³ The latest such excavations known to me were by F. R. and Mrs. B. Allchin at Piklihal; their final report has not yet come to hand.

two or more units. The clan name *Ghoṭaka-mukha* "horse-face" occurs in the *gotra* lists and the *Kāmasutra*,⁴⁴ while *Ghoṭamukha* is reported in *Arth.* 5.6 as a former master of political science. Earlier, the legend of *Śunaḥ-śeṣa* and his brothers, each of whose names means "dog's tail" and famous *gotra* names like *Śaunaka* (from *śvan* "dog", *śunaka* "puppy") carry one in the same direction. There is actually a Sanskrit word for "split clan", namely *gotrāvayava* (Pāṇ. 4.1.79). In Pāṇ. 4.1.173 the *Udumbaras* and others are (according to commentators) *avayava* components of the *Śālvas*; this is treated as a confederacy by Przyluski, but the two possibilities are not mutually exclusive. The etymology of *gotra* "cowpen" and the comment on Pāṇ. 4.3.127 implies that at some stage, the local *gotra* group had a distinguishing mark for its men and brand for cattle—presumably owned in common.

Śālva is given as tree with edible fruit by some commentators on Pāṇ. 4.3.166; a large number of brahmin *gotra* names⁴⁵ are edible tree- or animal-totems as among so many savages and for that matter among Latin *gentes*. We shall consider here only six examples of Sanskrit names ending in *karṇa*, none in the same category as *manda-karṇa* "hard of hearing". In the *gaṇa* *Sivādi* (Pāṇ. 4.1.112) are found (in the *Kāśikā* also) the clan names *ṛṇakarṇa* (var. *tūna-*), *māyūrakarṇa*, *masūrakarṇa*, *khar-jūrakarṇa*; respectively "grass-ear", "peacock-ear", "lentil-ear", "date-ear". These exclude the split totem; nor can they be used to describe shape or colour of a human ear. The analogy with *saptikarṇa* is clear, and one may point to a *śaunakarṇi* "son of dog-ear" in the *gotra* lists. Still better known is *Jatūkarṇa* "bat-ear". In each of these cases, the termination *-karṇa* signifies "descent from" rather than a split totem. Finally, the demon *Kumbhakarṇa* might have had ears like pot-handles (e.g. the Scottish "lug"). But the *kumbha* is often the homologue of the uterus and symbolizes a mother-goddess. This would explain the otherwise stupid account of the hundred Kaurava sons and one daughter of Gāndhāri being born through the intermediacy of *ghṛta-kumbha* ghee-jars; that many of these sons were patron

yakṣa cacodemons of northern towns⁴⁶ is known. *Vasiṣṭha* and *Agastya* had similar origin, being born from womb-jars, and the *ācārya* *Droṇa*'s name as well as birth-story throws him in the same category. *Drauṇi* and *Drauṇāyana* are again listed as *gotras*. *Droṇa*'s son *Āsvatthāman* bore in his forehead (from his very birth) a precious jewel—the symbol of a *nāga*. So, the Sanskrit termination *-karṇa* can signify "son of" as in *Muṇḍāri*, and may be associated with pre-Aryan elements. That a man has a good Aryan name does not mean that he had an Aryan father, nor even that he had a father at all.

6. Parallel development

It might seem at this point that I merely replace Austro-asiatic by *nāga* or some such change of name. The matter lies much deeper, being the gradual and progressive absorption of many distinct *ātavika* tribes into general Indian society which had had its own course of food-producing development since 3000 B.C. The influence of food-producing neighbours, infiltration by caravan merchants, Buddhist, Jain and other monks, brahmin priests and an occasional adventurer of some military capacity would generally introduce food-production and a class structure. From that stage, the course of assimilation depended upon the relative wealth and armed strength of the environment. The important point is that there was always a reciprocal influence. It seems to me that forgotten tribes show their existence in the onomasticon of peasant deities, particularly the mother-goddesses; *Śirkāi*, *Tukāi*, *Bolhāi*, *Meṅgāi*, *Soṅgāi*, *Kumbhaḥjā* (and of course the pre-Śākya *Lumbini*) seem to have no acceptable derivation. The folk etymologies are demonstrably eponymous, sometimes as crude as the world-derivations in the *Brāhmaṇas* and *Upaniṣads*. But there is nothing to show that any of these were Austro-asiatic nor that they all belonged to one pre-Dravidian or pre-Aryan group. Brahmin tradition lumped all kinds of aborigines together under the generic title *nāga* (cobra or more rarely elephant), presumably as snake-worshippers. The *nāga* cobra becomes a garland for *Śiva*, bed and canopy for *Viṣṇu*, the patron demon for many Buddhist *viḥāras* and a few cities. The

⁴⁴ *Ghoṭakamukha* is reported in *Kāmasutra* I. 114 as the authority for the third section of that work. *Hayagrīva* and *Hayavadana* may be adjectives, and *Hihaya* may or may not be connected with the horse, in spite of the termination.

⁴⁵ The best available *gotra* lists are in J. Brough; *The Early Brahmanical System of Gotra and Pravara* (Cambridge, 1953); actual *gotras* found in *Mahārāṣṭra* among the *Deśastha* brahmins have been collected by V. T. Śeṭe in his *Gotrāvali* (in *Marāṭhī*; Yājñavalkya Āśrama, Poona 1951).

⁴⁶ Sylvain Lévi, *Le Catalogue géographique des yakṣas dans la Mahā-māyūri*; *Journal Asiatique* 5. 1915 (i). 19-138; line 23 of the Sanskrit text, *Duryodhanas ca Srughneṣu*; but the list is composite, probably from many different sources: 1.60-siddhayātras *tathā Srughne*. For *Bharukaccha*, *Bharuka* in 1.17, *Asaṅga* in 1.43; for *Rājagrha*, *Vajrapāṇi* in 1.3, *Bakula* in 1.6., *Kumbhīra* in 1.101. Not that there need be only one *yakṣa* per city, but the principal guardian could be only one—here a different one for each particular tradition among the worshippers.

mother-goddesses are, whenever the number and wealth of their worshippers warrants it, identified with Durgā, Lakṣmī, or the like, "married" to the corresponding god and worshipped in suitably endowed temples. This brahminization reflects the underlying change from food-gathering in independent tribal units to food-production in a society that preserved endogamy and a (hierarchical) commensal tabu as features of its caste system. This preservation is due primarily to the fact that food-gathering remained a powerful supplement to agriculture till the forests disappeared, while clothing and shelter are not physically indispensable over most of India. It should be noted that Indian monastic tradition also has deep roots in the food-gathering tradition.

The danger of treating "Aryan" as a homogeneous unit over any considerable extent of time or space, or even in any large literary source formed over many centuries, may easily be demonstrated. The Madra tribe in the Mahābhārata was settled in the north-west, along with the allied Śālva, Udumbara, Bāhlika and Gāndhāra. Both Pāṇini and Patañjali came from or near this territory. The more learned Upaniṣadic philosophers (Bṛhad. 3.3.7 and 3.7.1) claimed to have wandered among the Madras to study the *yajña* fire-ritual, the very core of the sacred vedas. The local host is named as Patañcala Kāpya. Jātaka tradition supports this independently in placing Taxila as the main center of (vedic, Sanskrit and medical) education to which Gangetic princes and brahmins travelled by the great northern trade route, the *uttarāpatha*. For that matter, the Upaniṣads (Chānd. 5.3.5.11; Bṛhad. 2.1.6.2.) show brahmins at Kāśī and Pāñcala learning high philosophy from kṣatriyas; this perfectly genuine though unbrahminical tradition was continued in history by great Magadhan kṣatriya teachers like the Śākyan Buddha and the Licchavi Mahāvīra. Nevertheless, Karna as the ruler of Aṅgā in the east exchanges biting discourtesies with king Śalya of Madra-land, though the latter has agreed to act as Karna's charioteer in the imminent desperate and hopeless contest. The reproaches against the Madras and their neighbours are that: Women mixed freely with men, without restraint or modesty. All drank and ate meat. The ladies would cast off their garments to dance when intoxicated. . . . Still more shocking was slackness in observance of caste distinctions (8.30). "There a Bāhlika who has been a brahmin becomes a kṣatriya, a vaiśya or śūdra, or even a barber. From a barber he again becomes a brahmin. Having been a twice-born (*dvija*), he there becomes a *dāsa* again. . . . In the same family one (male) may be a brahmin while the rest are common workmen".

It does not seem to have struck the brahmin redactors of the *Mbh*, nor for that matter Śalya himself, that this kind of abuse sat ill in the mouth of Karna. Though ranked as a pre-eminent kṣatriya, Karna had no legal father, had been exposed by his unwed mother to hide her shame, rescued and brought up as his own son by a lowly professional chariot-driver. The censure only proves that the Madras and their allies retained the older Aryan custom whereby no man was degraded by his profession, while ritual had to be performed by some member of the family or clan. (Parenthetically, this last rule alone can explain the presence of so many tribal names in the brahmin *gotra* list, whether the brahmins were originally strangers adopted into the tribe or members of the tribe who specialized in pontifical functions). The quotation agrees very well with *sutta* 140 of the Majjhima-nikāya. The Pāli discourse reminds the brahmin Assalāyana through the mouth of the Buddha that in Yona, Kamboja, and other regions beyond the (north-west) frontier, there were only two castes: Ārya (= free) and *dāsa* (= slave); moreover, a person who had been an Ārya could become a *dāsa* and conversely. That is, the Madra-Bāhlika-Gāndhāra-Kamboja lands had developed a form of chattel slavery nearer to the classical Graeco-Roman model than to the complex and rigid caste system evolved in the Gangetic plain. As explained, the latter was better suited for the peaceful absorption of savage tribes in the warmer and wetter parts of India, under the conditions that prevailed before mechanised production became the norm. This cumulative difference had become significant by the end of the 4th century B.C. Earlier in the great epic, a Madra princess famous for her beauty had literally been purchased by Bhiṣma as legal wife for his nephew Pāṇḍu, with no more ado than over a basket of vegetables: *Pāṇḍor arthe parikrītā dhanena mahatā tadā* (Mbh. 1.105.5). This passage proved so embarrassing to later brahmin orthodoxy that several versions of the Mbh. insert discordant interpolations to explain it away. The *smṛtis* forbid bride-price for the upper castes (Ms. 3.51-3) as amounting to the sale of a daughter; therefore, in the high *ārṣa* form of marriage, the gift even of a pair or two of cattle to the bride's father was forbidden (Ms. 3.53). Nowhere is the wedding of Mādri declared Āsura as it would be by Ms. 3.31; it might be added that the custom is permissible and normal in some 80 per cent or more of the Mahāraṣṭrian population; brahmins do not hesitate to officiate (for a consideration) at such weddings.

The change from Ṛgvedic to Yajurvedic Aryans corresponds rather well to that between the ruder Germani of Tacitus and Caesar's Gauls of the later La Tène iron age culture. This is

another example of parallel development, not a suggestion that the Druids were really bramins or that Caesar must be later than Tacitus! When we look for totemic origins in the *gotra* lists, there is no implication that the brahmins concerned were comparable to medicine men of Austro-asiatic savages. Nevertheless, brahmin penetration of the priesthoods of comparatively savage groups is demonstrable or deducible from the earliest "Aryan" period down to the last century. The Manusmṛti interdict at a feast for the manes upon any brahmin who sacrificed for tribal organizations *gaṇānām caiva yājakaḥ* (Ms. 3.164) would otherwise have been quite superfluous. How explain the Śaigrava *gotra* (attested by a Mathurā inscription⁴⁷ though absent from surviving *gotra* lists) among brahmins except by association with the Śigru tribe of the R̥gvedic (RV. 7.18) Ten Kings' War? Is not the tabu upon the *śigru* ("Moringa pterygosperma") as food for ascetics (Ms. 6.14) of such tribal-totemic origin? The iguana is specially excepted (Ms. 5.18) from the tabu on the flesh of five-nailed creatures, but eaten today only by the lowest castes; what of *godhāśana* "iguana eater" as a gens in the *gaṇa* Kāśyādi (on Pāṇ. 4.2.116)? The hungry brahmin wanderer Baka Dālbhya (or Glāva Maitreya) spies in Chāndogya Up. 1.12 upon an assembly of dogs, led by a white dog (*śvā śvetaḥ*) as they dance hand in hand to perform an *udgītha* chant for food. This can only mean a fertility rite of a dog-totem clan; I have witnessed similar chants and dances among the lowest Indian tribal castes. A Kukuraka ("dog") tribe is listed among the formidable military tribes in *Arth.* 11; a cut above the *ātavikas* but dangerous to royal power. The historical name Kokerah for the region about Ranchi in Bihar may be due to the Kukurakas. We have already noted the brahmin *śaunaka* gens.

In the same way, modern linguists talk of a Koḷ language or group of languages. A Koḷiya tribe is clearly referred to in the Jātakas as having the Koḷ tree *Zizyphus juluba* as a totem; the Sanskrit name *badara* for the same jujube tree leads to Bādārāyaṇa, whom no one relates to the Koḷiyans. In Marāṭhī, Koḷī (like *nāga* further north) means the originally heterogeneous marginal tribe-castes that took late in history to agriculture and were often pressganged for portage in army service. The same

word also means spider and fisherman, presumably because the fisherman makes and uses a net to catch his prey as a spider his web. Here the derivation is not totemic but occupational; heavy deposits of microliths at certain favoured spots on the river bank surely indicate pre-historic fishing camps in Mahārāṣṭra. Men of the Koḷi caste still catch fish and keep up age-old cults at some of these places, as at Cās-Kamān. The Śākyans seem closely related to the śāka tree (*Shorea robusta*) and there existed two sub-groups among them known as reed-śākyas, and grass-śākyas the last being reminiscent of *trṇakarna*. Pippalāda as a *gotra* has a modern non-brahmin counterpart among the Pimpḷess (now a surname, once a clan) who, at their village Pimpḷolī, still observe characteristic tabus such as not eating off plates made of *pimpal* (*Ficus religiosa*) leaves. This should place the Udumbaras in proper perspective.

There still exist tiny remnants of a *gavalī* tribal caste, who live solely by pasturing cattle. To most city-dwellers *gavalī* means only "milk-man" whatever his caste. Remote villages report strong traditions which show that the now extinct *gavalīs* were relatively more numerous at one time and relatively more important in the rural economy. This sounds like an Aryan invasion, but I have been unable to find any indication of their possessing horse-chariots, the heady *soma* drink, the over-developed fire ritual or the powerful aggressive tendencies of vedic Aryans. Archaeologically, their successive waves appear in the western Deccan to be responsible for megaliths, rock-engravings of a peculiar type, upland terraces not meant for the plough, and certain remarkable mortarless structures (*vādage*) of undressed stone that are traditionally cattle enclosures though never used now as such. The terraces and *vādage* are sometimes ascribed to the mythical Age of Truth (*satya yuga*) by older peasants. Occasionally, the pastoral cults survive in the name of a comparatively rare patron god of cattle: *gavalūji-bāba*. Still rarer is the use of the term to describe a village. One such is Gavalīyācī Uṇḍavaḍī not far from Bārāmāṭī, with a companion village Corācī Uṇḍavaḍī. The village Corācī Aḷandī has a tradition that the qualification "thief's" was originally genitive plural: *corāmcī* "of the brigands". The origin of this latter village can be traced back to long before the 8th century A.D. The added *cora* both at Aḷandī and Uṇḍavaḍī merely denotes a settlement of tribal origin which long retained habits of brigandage, taking to plough culture much later than neighbouring villages. This would be impossible to restore without field work, merely from the etymology of *gavalī* and *cora*; in the latter case, distant villagers invent some repentant thief who originally settled the

⁴⁷ H. Lüders noted in reading the Mathurā inscription (*Epigraphia Indica* 9.247-8) that the brahmin of the Segrava *gotra* there named was treasurer of the Śaka kṣatrapa king Śoḍāsa; the title *gamjavara*, of which this seems to be the earliest mention, is a loan word from the Persian *ganjwār*. Lüders further comments that the legendary preceptor of ācārya Moggaliputta Tissa was a Siggava.

village of Aḷandi. The primitive goddess Bolhāi is reported by her senior worshippers, the Vājī ("horse") clan at Pāsaṇe, to have been taken by coras to her present location, which represents tribal cult migration quite accurately.

A modern observer could report (*New Yorker*, April 18, 1959, p. 119) that in the neighbourhood of Pawa in north-eastern Congo: "The pygmy women used a kind of sing-song in their speech . . . and there were experts who believed that this was the vestige of an ancient pygmy language; nowadays the pygmies had no identifiable language of their own, merely speaking that of whatever settled tribe they lived near. . . . They had a natural balance of trade — the sort of mutual dependency that naturalists call symbiosis. The pygmies killed game and gave some of it to the villagers, whose normal diet lacked proteins, and in return got the products of agriculture — mainly bananas — which, as nomads they did not grow themselves. Nowadays . . . the pygmies are accustomed to a steady supply of bananas and this keeps them from disappearing into the forest for very long. The men may hunt for days on end, but meanwhile the women will go back to the villages to fetch bananas and this ties them all down to some degree." No better illustration could be found of the development of primitive languages in relation to food gathering and food production. Now add the following important remarks by T. Burrow (*Trans.* 19, *Bull. Ramakrishna Mission Inst. of Culture*, Feb. 1958): "The number of loan-words in Sanskrit, which cannot be explained as either Dravidian or Munda, will remain considerable. It may very well turn out that the number of such words which cannot be so explained will outnumber those which can be. This is the impression one gets, for instance, from the field of plant-names, since so far only a minority of this section of the non-Aryan words has been explained from these two linguistic families. If we take, for instance, the name of the jujube (*Zizyphus jujuba*), we find four synonyms, all obviously non-Aryan words, namely *kuvala* or *kola*, *karkandhu*, *badara* and *ghoṇṭā*; and none of these has been explained out of either Dravidian or Munda. Evidence such as this leads to the conclusion that there must have been several non-Aryan languages or families of languages which exercised an influence on the vocabulary of Indo-Aryan". Inasmuch as the total number of words in use has grown with social production, it may be better to concentrate upon parallel development rather than invent fictitious origins.

Language is surely a means of exchanging ideas, which cannot precede the exchange of surplus. This implies that any language common to more than a handful of people must have been pre-

ceded by commodity production and exchange on a corresponding scale. But it is known that, in the most primitive societies, such exchange is not simple public barter with a basic standard of equivalents modified by haggling or by the laws of supply and demand. On the contrary, the exchange appears at its most primitive level in the form of gifts that cannot be refused and must ultimately though not immediately be compensated by a reciprocal gift from the recipient. Moreover, these gifts are only to be made between fixed persons⁴⁸ of different tribes in a special relationship, "trade friends". Within the tribe, such gifts are obligatory, dependent upon the status of the giver, with no idea of compensation — a form of distribution of the surplus. It seems plausible that at a still earlier period, the tribe was fused out of individual totems on the same basis, with exchange of human beings in some form of exogamous "marriage" as a concomitant of the transfer of food (often the special totem product) or techniques. If so, the development of language cannot be separated from the succession of pre-historical stages through which a given society has passed.

The position stated does not approach the formalism of Marr's Japhetic Theory which derived all Caucassian languages and perhaps all languages from the four mystic syllables *yon*, *ber*, *sal* and *roś*. It differs also from the Durkheim-Levy-Bruhl⁴⁹ type of sociology which takes "pre-logical" mentality as a fixed characteristic of certain ethnic groups, not as the concomitant of the various stages of development through which the particular group reached its actual level of social production. One may leave out of discussion the higher mentality which takes slums, world wars, massive colonial suppression and nuclear bombs as logical assets of civilization; but two questions remain. Did not the superior "logical" people once pass through the same "pre-logical" stage, say when their ancestors could make only the simplest tools of stone? Secondly, what caused the change from the pre-logical to the logical mentality? One possible answer has been suggested in this note.

⁴⁸ See particularly, B. Malinowski, *Crime and Custom in Savage Society* (London) 1940, pp. 22-25; also, Margaret Mead: *Sex and Temperament in Three Primitive Societies* (Mentor Books, New York 1950): pp. 19-20 and 31 for the Arapesh.

⁴⁹ L. Levy-Bruhl, *Les Fonctions mentales dans les sociétés inférieures*, translated into English as: *How Natives Think* (New York, 1925).

Two years prior to his sudden death Professor D. D. Kosambi published an article in the international magazine *Man* (1963, Vol. LXIII, No. 60) on "Prehistoric Rock Engravings near Poona" and we had the good fortune of seeing these engravings with him and he hoped we would undertake a fuller archaeological examination.

The question before us is: Are the engravings natural or artificial, that is man-made? The late Professor Kosambi (1963) thought that these were carved by man, but it could not be decided who this man was nor could we know anything about the significance of the marks, because there was no local tradition about them. He cites the view of old villagers that the plateau was occupied at one time by pastoral (*gavali*) migrants from the north who did not use the plough.

Since the microliths are also found on the plateau, Kosambi assumed that the plateau was inhabited by people in prehistoric times and in the same strain argued that "A set of over 50 cairns, 2300 yards west by south probably represents a necropolis which re-used some engraved boulders" (1963, p. 58).

An excavation on the site and elsewhere, for instance at Bhosari, 15 km. from Poona on the Nasik road, could, he thought, tell us whether these were prehistoric burials or not.

For a proper and fuller understanding of the problem, we have to proceed slowly, step by step. For instance, we should establish that:

- (i) the engravings are not natural;
- (ii) if made by man, how—with what tools—and when, and why he has carved these engravings;
- (iii) the so-called cairns are true cairns and not residuary clusters of stones, left by weathering; and
- (iv) the microliths really belong to a prehistoric period.

Professor Kosambi was very anxious that we (the Deccan College) or some other archaeologist (he had Dr. Allchin in view) should take up these problems, though he seemed to be convinced that the entire complex was prehistoric. Unfortunately, we could not devote any time to any of these problems as we were engaged with the problems on hand. In this short paper we have taken up the problem of the genuineness of the carvings, leaving the other two, viz., cairns and microliths, for a future investigation though our provisional views on these will also be given.

The problem of the carvings is not so easy or simple as Kosambi seems to have assumed. For unlike many genuine engravings which are found on vertical rock surfaces, these Vetal or Pashan hill engravings are found on a plateau which is strewn with flattish boulders. So the effect of weathering on such exposed rock surfaces under various climatic conditions has got to be taken into account, as well as the character of the rock and the work of micro-organisms. Though a number of areas have been referred to by Kosambi in his brief article we have selected for a close study a part of the Vetal hill plateau which lies about 1 km. south of National Chemical Laboratory, Poona.

On our way to Vetal hill from Pashan side we came across so-called 'basalt bombs' (Kosambi, 1962). The formation of 'basalt bombs' is clearly connected with the typical spheroidal weathering of basalt and this process of weathering is mainly controlled by the joint patterns of basalt. Regarding these 'basalt bombs' Kosambi says, "The grooves exist on several stones, and are not to be confused with the 'basalt bombs' which are often seen in the Deccan rocks. The latter are generally hard egg-shaped cores of basalt surrounded by many crumbling layers of soft rock. Weathering gives the whole bomb a curious resemblance to the engraved oval, though the latter do not have wider, deeper, and smoother in place of the narrow-inter-strata lines. The bombs may have supplied the models for primitive megalithic builder's marks" (Kosambi, 1962, pp. 135-36).

From this narration it becomes very clear that there is a very close similarity between the megalithic engravings and the natural grooves produced by spheroidal weathering of basalt (Plate II A). The only test, according to Kosambi, for distinguishing man-made grooves from the natural ones, is the nature of surface texture, width and the depth of a groove. Accordingly man-made grooves are supposed to be uniformly smooth, quite wide and deep (say about 2 to 3 cm.).

Against this background we carefully examined the grooves associated with engravings of Vetal hill. We mainly studied the

joint system of the rock outcrop which has been grooved and the depth, width and smoothness of various grooves.

The rock exposed on the plateau of the Vetal hill is mostly compact, grey, slightly amygdular and porphyritic basalt. It is traversed by a number of joints, both large and small, running mainly in NS-EW directions and sometimes in ESE-WNW directions. The surface of the rock is black and is covered with lichens and fungus. The growth of these micro-organisms is not uniform and many times a circular pattern in their mode of growth is also observed. The plateau is subjected to sheet flooding during the monsoons and channel flow is restricted to small gullies and rilllets. The engravings occur on a outcrop with a very gentle slope towards the west. The engravings are mostly circular and sometimes elongated oval shaped (Plate I). The figures with 3 or 4 concentric circles are quite common with a maximum outer diameter ranging from 40 cm. to 70 cm. The depth as well as the width of these grooves were found to vary between 2 to 3 cm. The surface of the groove is not always smooth and at times it is as rough as the surfaces of a natural groove in the same area. Our sample survey of the rock engravings on Vetal hill suggests that in an area of about $\frac{1}{2}$ km. the total number of such figures was about 50 and its further break-up is as follows :

32% of the figures are complete with 3 or 4 concentric circles.

28% of the figures are complete with 2 or 1 concentric circles.

24% are incomplete with 2 or 1 circles.

8% are doubtful but nearly circular with one or two concentric circles.

8% are incomplete and in the process of making nearly circular outline.

In the last two groups the depth and width of grooves are very small and the smoothness of the surface is highly variable. In the first three groups the smoothness is also variable and there is comparatively somewhat more uniformity in the width and depth of various grooves. From a careful study of the grooves belonging to the last two groups it can be said that such circular grooves can develop in nature in the following ways :

1. The formation of a more or less straight or slightly curved groove due to :
 - (a) deepening of joints (both macro and micro) due to periodic thermal and water action ;
 - (b) removal of siliceous veins and amygdales due to weathering and further deepening of the empty portion by water action ;

(c) the action of micro-organisms.*

2. The flow of water deepens these grooves and also smoothens their surface but not uniformly.
3. Rounding of the corners of joints due to natural weathering processes makes the straight joints slightly curved at least at their ends.
4. Lengthening of these curved portions of joints due to headward erosion of small concentrated water flow in these grooves.
5. More or less completion of the circle due to the meeting of advancing grooves in opposite directions (Plate II C).
6. These grooves are seen not only on the surface of a rock but also in its section and that too, fairly regularly spaced (Plate I A).

In this way many of the circular and nearly circular or elliptical engravings from Vetal hill and some shown by Kosambi (1963, p. 57) are quite likely to have formed due to natural weathering processes. Many of the deep grooves are rough, while some of the very shallow grooves are having very smooth surfaces thereby suggesting their natural origin.

Some of the engravings with three or four concentric circles, even though quite likely to have formed in a manner described above, are really problematic. They are not so common even in similar environment not only on Vetal hill but also in some of the trap plateau examined by us in Poona District. Are they really man-made ?

This aspect might be examined archaeologically. In the first place natural circular grooves as shown above occur (i) not only on the surface, but (ii) also in the section of the same boulder, and (iii) below the surface ; we saw one on the newly made road from the Vetal hill to the Poultry Farm.

Secondly, if the grooves were made at a subsequent period, then their surface would look in some way different from the unworked surface. But this is nowhere the case. The grooved surface and the ungrooved surface are identical in their colour and texture. This indicates that both have undergone identical (weathering) influences.

Thirdly, granted that these grooves are man-made with tools or implements, when were these made ? At the moment, we find nothing but chunks, nodules and flakes of chert, agate and chalcedony strewn on the Vetal plateau. Among these one can

* Such perfectly concentric circles have been observed in the limestone of upper Vindhyan formations in Central India (Mishra *et al*, 1962, p. 765) and they are thought to have formed due to organic action on shaly limestone (Plate II D).

pick up partly worked cores, some fluted points, borers and scrapers and tiny microlithic blades.

Kosambi thought that the microliths must (might?) have been used for the purpose of engraving the grooves. In the first place, these are too small, and engraving is (was) not done with lunates, or backed blades, but burins, a chisel-edged tool, and hence also called an engraver. Very few burins are found in Indian microlithic collections, and we do not know whether any true burins occur in Kosambi's collection. We have so far not found any burins on Vetal hill.

Secondly, the grooves are too broad and deep to be effected by such burins. Moreover, they have not been smoothened as thought by Kosambi.

Thirdly, the argument from ethnology has no validity. Vetal plateau is mostly stony, with a little soil cover. No good cultivation is really possible even with an iron plough. Hence it is that even in 1968, the *Dhangars* (shepherds) graze their goats and sheep here. This is significant. Because even for cattle grazing the plateau is not suitable. Thus when we view the problem under an environmental background it will be apparent that

- (i) the grooves are natural, and not man-made;
- (ii) the microliths are not suitable for making such large, broad and deep grooves;
- (iii) if such tools had ever been used, they (their edge and side) would soon become blunt (as found by us by actual experiments), and at least a few of such blunt-edged or pointed tools should be found on the plateau, particularly around the boulders bearing the engravings. But none have been found.

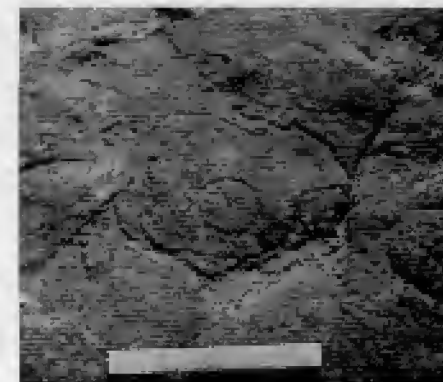
Then how do you explain the existence of these stone tools? These belong not to one period, as the late Dr. Kosambi thought, but at least to two widely separate periods. The first and the earliest is the Middle Stone Age, now dated by C-14 date from the Mula Dam to C-30000 B.P. To this period belong the larger tools on agate, chert, jasper and consisting of points, borers, and a variety of scrapers.

Vetal hill has an almost inexhaustible supply of the raw material for the tools. Apparently Vetal plateau has served as a camp and knapery of the Middle Stone Age man, because he found the raw material very easily and some game as well.

At a much later date came the Late Stone Age man, who made microliths. And it is to Dr. Kosambi's credit that he was the first scholar to recognize their presence on the Vetal plateau.

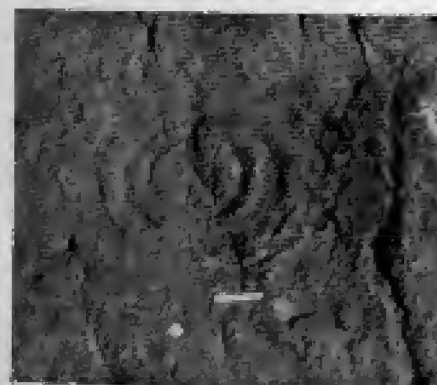


A.

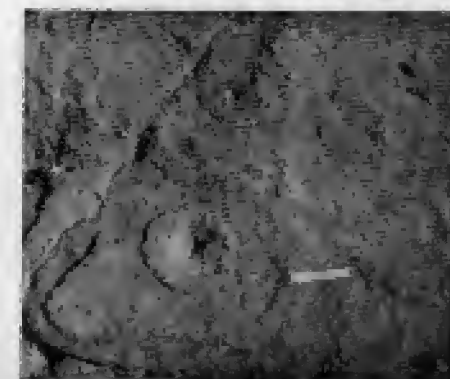


B.

- A— An engraved boulder in Prof. Kosambi's house.
- B— } Rock surfaces from Vetal hill area showing the grooves
- C— } resulting from the joint pattern systems and spheroidal
- D— } weathering.



C.



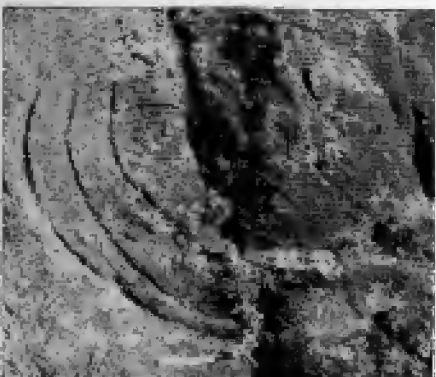
D.



A.

B.

- A— Grooves forming concentric circles due to spheroidal weathering.
- B— } The rounding of grooves in formation.
- C— }
- D— Concentric circles on the Vindhyan limestone,



C.

D.

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ACKNOWLEDGEMENTS

We are extremely grateful to Smt. Kosambi for kindly allowing us to study and photograph some of the rock engravings from her bungalow.

PLATES

- Plate I A— } An engraved boulder in Prof. Kosambi's house.
- B— } Rock surfaces from Vetal hill area showing the grooves
- C— } resulting from the joint pattern systems and spheroidal
- D— } weathering.

- A— Grooves forming concentric circles due to spheroidal weathering.
- Plate II B— } The rounding of grooves in formation.
- C— }
- D— Concentric circles on the Vindhyan limestone.

Marxist interpretation of Indian history began with Marx himself. His comments in the two articles published in the *New York Tribune*, in 1853 ("British Rule in India", and "Future Results of British Rule") contained remarkable insights into the impact of British rule in India. In essentials that analysis remains of lasting value and has ever since formed the bedrock not only of the Marxist, but also of all progressive evaluations of the history of British imperialism in India. The two articles also include certain general statements about India before the British conquest; and these are summed up in the following passage:

"Indian society has no history at all, at least no known history. What we call its history, is but the history of the successive intruders who founded their empires on that unresisting and unchanging society."

Marx explained the passivity of Indian society by the existence of the caste-bound, traditional village communities, which had completely to depend upon "Asiatic despotism" to provide irrigation works necessary for the existence of agriculture. In terms of relations of production, the system was marked by a total "absence of (private) property in land". This also formed the kernel of Marx's view of the Asiatic mode of production, which was for the first time enunciated in these articles.¹

* This is a revised version of a paper presented at the First All-India Conference on Marxian Approach to Research in Social Sciences, organised by the Indian School of Social Sciences, Trivandrum, June 5-9, 1969.

¹ These articles have been frequently reprinted. The most useful edition is Karl Marx, *Articles on India*, Bombay, 1951, pp. 21-29, 66-73.

Five or six years later, Marx composed certain notes, now published in English under the title *Pre-Capitalist Economic Formations*, London, 1964. In these notes, a more closely argued analysis is provided of the "Asiatic Form". It is said to arise out of the primitive community and to be at once the most primitive of the various systems of property, and the most widespread (embracing Asia, Russia and other Slavonic regions, ancient Celts, etc.). Marx no longer gave to irrigation the crucial position he had ascribed to it earlier, though it continued to figure in his analysis. He contrasted the Asiatic with two other apparently parallel forms, namely the classical city-oriented society, characterised in its advanced stage by Slavery, and the 'Germanic' form, which led in its ultimate development to Serfdom. In line with his previous views, Marx regarded the Asiatic as the least dynamic of all the three forms, and declared that it "necessarily survives the longest and most stubbornly".²

There is little reason to believe that these ideas represented Marx's final, considered judgement on the history of Asia. On the contrary, the founders of Marxism did not further elaborate these points; and explicit references to the "Asiatic (Oriental) mode" (though not to the political institution of 'Asiatic despotism') become very rare, and after the appearance of *Capital*, Vol. I, cease altogether. Even in *Capital*, Vol. I, while there are separate passages on the village community (as representing a form of division of labour) and of the economic position of the Indian 'magnate' (as a surplus-appropriator, presiding over production and reproduction on a progressively increasing scale, but without the intervention of capital),³ there is no attempt at showing them as parts of a single system.

A further stage in the erosion of the ideas held earlier by Marx and Engels is marked by Engels' *Anti-Dühring*, 1878. Here the earlier thesis is indeed repeated that the surviving primitive communities "from India to Russia" served as the basis for "Oriental despotism".⁴ Nevertheless, when discussing the state, Engels provides no place for the Asiatic mode of production as a determining factor for a particular form of state: Only the slave-owners', feudal, and bourgeois states are listed.⁵ Equally significant still is Engels' statement that the Turks introduced "a form of feudal ownership of land" in the countries of the East conquered by them (among which, from the context, India is

² See *Pre-Capitalist Economic Formations*, 68-83.

³ *Capital*, I, ed. D. Torr, pp. 350-52, 610.

⁴ *Anti-Dühring*, Eng. ed., Moscow, 1947, p. 271.

⁵ *ibid.*, 416-17.

plainly included).⁶ Or again elsewhere, the Moors of Spain are classed among the civilized and their Christian conquerors among the barbarians.⁷ Such statements hardly leave room for any belief in an unchanging, stagnant Asiatic society.⁸

Moreover, Marx's own failure to publish anything out of the MS of the *Pre-Capitalist Economic Formations* must be construed as evidence of his hesitation to put forward as his firm opinion what was little more than speculations. Hobsbawm can, therefore, hardly be right in asserting that there was "at least on Marx's part (is he then not sure about Engels?), no inclination to abandon the Asiatic Mode."⁹

The seal was indeed set on such abandonment by Engels' *Origin of the Family, Private Property and the State*, 1884. Though published after Marx's death, it was based on his notes. It made not the slightest mention of the Asiatic system, though it attempted the most detailed historical generalisation ever set in writing by either Marx or Engels.

It is true that Marx and Engels might now have considered the village community taken in isolation as a survival of the stage of primitive communism—a stage which they began to postulate following their acquaintance with Morgan's work. But the silence over the Asiatic mode is not to be explained simply on the ground that it was transferred by them to the category of the "archaic type", and so covered now by that designation. Actually Engels distinguished only four stages of society. The first was primitive communism; and the other three were systems of exploitation. "Slavery was the first form of exploitation, peculiar to the world of antiquity; it was followed by serfdom in the Middle Ages, and by wage-labour in modern times. These are the three great forms of servitude, characteristic of the three great epochs of civilization."¹⁰ Faced with this passage, which he quotes, Hobsbawm avoids saying directly that the Asiatic mode was held by Engels to be a form of primitive communism—which would be an absurd presumption in view of Marx's own portrayal of the Indian magnate as a surplus-appropriator. He seizes upon the word "civilization", and proclaims that Engels regarded the Asiatic mode as 'belonging to the pre-history of

'civilization', so that Engels presumably omitted any mention of it because he felt it to be neither primitive communism, nor a civilized form of exploitation!¹¹

If we dismiss such strained reasoning, the question remains, why did Marx and Engels modify and ultimately abandon their earlier theory of the Asiatic mode? Since Marx never elaborated the theory in published form, except in two relatively obscure newspaper articles, there was little cause for him to explain the reasons for no longer holding the same views as before. On our own part, we do not find it difficult to conjecture two very good reasons for this change of opinion.

The first could be a recognition by Marx of the obvious limitations in his own information when he had worked out his views in the eighteen fifties. His remarks on India had been based on a reading of English Parliamentary papers and Bernier's *Travels*. Among the British administrators at that time there was a strong tendency to emphasize the institution of the village community in order to justify a paternalistic form of government. It coloured very deeply most of the official reports and it ultimately found its most systematic (and exaggerated) expression in Sir Henry Maine's works. On the pre-British history of India proper, Marx appears to have done little reading except towards the last years of his life,¹² precisely in the period when his own references to the Asiatic mode disappear altogether. In these last years he also read with interest and approval Kovalevsky's work on Communal Landholding, 1879, which indicated a far more complex picture of the Indian village organization and of its evolution than Marx had earlier allowed for. Marx now clearly noted the emergence of private property within the Indian community, leading to the rise of a contradiction within it.¹³

¹¹ Hobsbawm, op. cit., 52n. See also Wittfogel, *Oriental Despotism*, 386, for a similar argument.

Wittfogel and Hobsbawm may not find it equally easy to dispose of the implications of Engels' editorial comments in the 1888 edition of the *Communist Manifesto*. Engels now wished to qualify the famous proposition in the *Communist Manifesto* that "the history of all hitherto existing society is the history of class struggles" by adding the adjective "written" before the word "history". He explained that the sole exception to the general rule was the primitive society, whose survivals were found in both continents, from India to Ireland. He made no geographical exceptions, whatsoever, and therefore left no room for a system of (class?) exploitation without class struggle, such as the "Asiatic".

¹² As shown by his notes from the works of Elphinstone and Sewall, now published in English as *Notes on Indian History* (664-1858), Moscow, n.d.

¹³ See Daniel Thorner, "Marx on India and the Asiatic Mode of Production", *Contributions to Indian Sociology*, IX, 1966, pp. 60-62.

⁶ *ibid.*, 264.

⁷ *ibid.*, 274.

⁸ Since Engels' work in MS had been read aloud to Marx, who also contributed a chapter to it, it must be assumed that Engels' statements carried his approval.

⁹ Hobsbawm, Introduction, *Pre-Capitalist Economic Formations*, p. 58.

¹⁰ Engels, *Origin of the Family, Private Property and the State*, Eng. ed., Moscow, 1948, p. 248.

Besides the weaknesses in the information available to Marx and Engels during their earlier years, there was the equally important question whether the acceptance of the theory of the Asiatic mode would not make the vast majority of mankind an exception to the materialistic conception of history, as set out in the *Communist Manifesto* and summed up in the celebrated passage of the Preface to the *Critique of Political Economy*, 1859. Were the class struggles, and historical changes emerging through them, to be regarded only as a European phenomenon and by no means universal, at least before the conquest of the world by capitalism? In view of the fact that Marx and Engels never either explicitly or indirectly confined their general propositions about the role of class struggles in history to Europe alone,¹⁴ it would not have been easy for them to hold simultaneously to a completely contrary view.

For the same two reasons, but particularly for the second, Marx's revolutionary followers did not generally accept or stress the Asiatic mode. On the contrary, when the revolutionary tide rose high in Asia, the propagandists of Imperialism turned to this theory, and rescuing it from the early Marxist texts used it to jeer at the revolutionaries. In 1957 Wittfogel published his *Oriental Despotism—A Comparative Study in Total Power*, which offered in the most systematic form, and duly embellished with terms and ideas of modern sociology, a detailed elaboration of the unfortunate theses that Marx had once propounded.

Neither as a propagandist work nor as an academic exercise did the reputation of Wittfogel's work survive the passage of even half a dozen years. However, modern revisionism has now picked up the weapon that Imperialism has all but discarded.

During the sixties we have been privileged to witness the curious phenomenon that in spite of the general inability of Asian Marxist scholars to recognize the existence of the Asiatic mode of production, certain Marxists of western European countries have begun to insist that they know better and have 're-

¹⁴ Marx and Engels wrote again in 1879 in a careful draft of a letter to the German Social Democrats that "for almost forty years we have stressed the *class struggle as the immediate driving force of history*, and in particular the class struggle between the bourgeoisie and the proletariat as the great lever of the modern social revolution". (Marx & Engels, *Correspondence*, Calcutta, 1945, pp. 332-3. Italics ours). There is no nonsense about excluding Asia, Africa and North and South America from the proposition in the first clause.

opened' the debate on the subject among themselves.¹⁵ In this the recovery of Marx's MS *Pre-Capitalist Economic Formations*, has played the same part as that of his early *Economic and Philosophical Manuscripts* has done in the attacks on 'traditional' Marxism in the realm of sociology. Introducing it to the English reader Hobsbawm declares that "it can be said without hesitation that any Marxist historical discussion which does not take into account the present work—that is to say virtually all such discussion before 1941 and (unfortunately) much of it since—must be reconsidered in its light".¹⁶ This is really a strange kind of dogmatism, since it assumes that the entire previous work based on the essentials of the published revolutionary teachings of Karl Marx and the actual experience and studies of Marxists, becomes immediately vulnerable once certain words directly set down on paper by Marx himself, are discovered, whatever be the circumstances in which they were originally composed.¹⁷

The essential purpose in the attempted restoration of the Asiatic Mode is to deny the role of class contradictions and class struggles in Asian societies, and to emphasize the existence of the authoritarian and anti-individualistic traditions in Asia, so as to establish that the entire past history of social progress belongs to Europe alone, and so in effect to belittle the value of the revolutionary lessons which may be drawn from the recent history of Asia.

"The history of hydraulic (i.e. Oriental) society suggests that class struggle far from being a chronic disease of all mankind, is the luxury of multcentred and open (i.e. West European) societies."¹⁸ These are the words of Wittfogel. Neither Hobsbawm nor Goldier would go so far. Both concede some change and some class-exploitation within 'Asiatic' societies.¹⁹ Yet they agree in treating Asian societies as only primitive class societies. As Hobsbawm puts it, "the Asiatic system is therefore [his

¹⁵ See Hobsbawm's Introduction, *Pre-Capitalist Economic Formations*, p. 64 & n. with references. M. Goldelie of Paris has published a long article on 'The Notion of "Asiatic Mode of Production" and the Marxist scheme of the Evolution of Society', an abridged English version of which appeared in *Enquiry*, N.S. II, No. 2, pp. 28-48, & No. 3, pp. 76-102. There are reports of fresh interest in the subject in the Soviet Union.

¹⁶ Hobsbawm, *op. cit.*, p. 10.

¹⁷ Goldelie by putting together various statements made by Marx in these notes, and at other times, along with some facts independently collected by Goldelie himself, constructs a definite scheme for the Asiatic Mode, which is quite unreal and deceptive. Cf. D. Thorner in *Contributions to Indian Sociology*, IX, p. 63 n.

¹⁸ Wittfogel, *Oriental Despotism*, p. 71.

¹⁹ Hobsbawm, *op. cit.*, p. 61.

inference from Marx] not yet a class society, or if a class society, then it is the most primitive form."²⁰ Goldelier makes essentially the same point asserting that the Asiatic society displays "the unity of the community structures and of class-structures".²¹ Since both of these writers (Hobsbawm only implicitly, however) hold that the Asiatic mode continued to prevail until modern times in all areas outside Europe in varying degrees of stagnation, it is obvious that their difference with Wittfogel is only of degree. It suffices therefore to urge against them the same arguments as have been advanced by numerous scholars of all persuasions in bringing down Wittfogel.²²

II

Once the Asiatic mode was given up by Marx and Engels, as a framework for analysing diverse societies existing outside Europe, there was a natural tendency for them and their followers to speak as if the succession of social stages established by them for Europe, viz. Primitive Communism-Slavery-Feudalism-Capitalism (henceforth abbreviated in this paper to P-S-F-C) was of universal application. Engels in a letter to Marx had actually spoken of Ottoman Turkey as "semi-feudal",²³ and it could be deduced from a statement already cited, from the *Anti-Dühring*, that the Turkish conquest led to the introduction of feudalism in India.²⁴ However, on this matter, an explicit pronouncement was not made by Lenin or by other authoritative Marxists. This came only with the powerful impression that the Chinese Revolution created during the '20s, with its clear evidence of peasant struggles within the womb of the old agrarian society, reminding every one of the agrarian upsurge in the Revolutionary France of 1789. This was the best refutation of the theory of the Asiatic mode; and the Leningrad discussions of 1931 resulted in a general acceptance of the international applicability of the P-S-F-C pattern.²⁵ The last word was said on the matter by Stalin in his classic essay on Dialectical and Historical Materialism, 1938.

²⁰ *Ibid.*, p. 34.

²¹ *Enquiry*, N.S. II, 3, p. 88. Unlike Hobsbawm, Goldelier believes that Western slave society developed out of the Asiatic Society.

²² My own critique of Wittfogel will be found in "An Examination of Wittfogel's Theory of Oriental Despotism", *Enquiry*, 6, pp. 54-73.

²³ Marx and Engels, *Selected Correspondence*, 1846-1895, Calcutta, p. 363.

²⁴ *Anti-Dühring*, Moscow, 1947, p. 264.

²⁵ Unluckily, no detailed report of these discussions seems to be available in English.

Much though this may be mourned as a mechanical application of a "standard unilinear" scheme for the whole world, there is no doubt that it provided significant stimulus for fruitful Marxist work in the sphere of Indian History. It is true that in the face of Marx's definite statements of 1853, there have been attempts, particularly in the writings of Soviet Indologists, to ride two horses at the same time. India has been taken to be an 'Asiatic Society' as well as Feudal; and the two propositions are reconciled by taking the first to be a form of the second.²⁶ This is surely a theological, and not a scientific, way out of the dilemma. However, once it was accepted that pre-British Indian society *could* be feudal, Marxists began to look in India for class-struggles and those other features that characterized the production relations of European feudalism. As a result Reisner and W. C. Smith recovered from oblivion the peasant revolts of the 17th century.²⁷

This phase of Marxist historiography also produced S. A. Dange's fantastic work, *India from Primitive Communism to Slavery*, Bombay, 1949, describing in minute detail the transition P-S in India without almost any reference to archaeology or genuine history. While the principal weaknesses of this work must be attributed to its author, it is also true that it presents in a concentrated form the defects inherent in the compulsory transposition of the standard P-S-F-C pattern to every society without exception. For, the moment a conscientious historian tries to go beyond the most simple generalities and begins examining his evidence in some detail, he is compelled to make so many qualifications that the basic classification loses much of its meaning.

Even at the level of theoretical generalization no particular logical sanctity attaches to the P-S-F-C chain of succession. Exploitation begins when the individuals or communities in any society become capable of producing a surplus. Various forms

²⁶ Official Soviet Indology, therefore, declares itself convinced that "the works of Marx and Engels contain observations on the specific features of Indian *feudalism* which are of basic methodological importance", V. Pavlov, *Indian Capitalist Class, A Historical Study*, Delhi, 1964, p. 1 (Italics ours).

²⁷ Reisner's papers, to which I have seen reference, have not been printed in English. Smith's pioneer essay, "Lower Class Uprisings in the Mughal Empire" appeared in *Islamic Culture*, 1946, pp. 21-40. This, together with his earlier article, "The Mughal Empire and the Middle Classes", *Islamic Culture*, 1944, pp. 349-63, leaves one in no doubt that he was thinking of the 17th century as the last phase of feudalism, containing within it the seeds of capitalism.

of relations of exploitation can be imagined: (a) A tribe of peasant-warriors subjugated by another similar tribe and forced to pay part of the surplus to it; (b) peasants forced to pay the surplus to a ruler or chief or to a number of exploiters holding a variety of rights; (c) peasants forced to work *gratis* on lands of others; (d) servile labourers belonging to menial castes working on fields of men of superior castes; (e) slave-labourers in agriculture and crafts, and so on. Now (b) and (c) might be akin to serfdom; and (d) and (e) to slavery, in that the labourers possess neither means of production nor mobility. But in many cases even such rough classification would become difficult, as for example in that of (a). In any case, why should it be supposed that societies where forms (d) and (e) are more prominent have always preceded those where (b) and (c) prevail? One thinks immediately of the "new" Negro slaves in the United States, which grew on the foundations of capitalism.

Secondly, at any given time various forms of exploitation might prevail side by side, or in different countries, depending upon a number of factors, such as climate, demography, etc., whose influence on conditions of production was much greater in the ages previous to the rise of capitalism. The *Communist Manifesto* recognizes that it is capitalism alone, which, "through its exploitation of the world market, has given a cosmopolitan character to production". We can imagine how the whole context of agrarian relationships could be different in rice-producing areas like Bengal and Kerala, and the three-field wheat-barley producing areas of medieval Europe. Varying man-land ratios in different countries were bound to influence production relations, especially since population adjustments could only take place over a long period of time. More important still was the variety in technologies. The spread of technological devices was so often such a slow process (exemplified by the delay in the introduction of the vehicular wheel from ancient Sumer to Egypt, or again the equally long delay before India accepted such Chinese inventions as paper, sericulture, gunpowder, printing, etc.) that it is most unlikely that the technological basis of production in any two sub-continental regions could have been fundamentally similar at the same time.

Thirdly, it is quite possible that if out of a number of factors, one determinant was different, the entire mechanism of exploitation (and so the character of property) might be entirely different. Let us suppose that given a technique of production most suited to peasant agriculture, there is a favourable land-man ratio in conditions of production-for-use. This may lead to serfdom, i.e., to dispersed manorial units with individual lords tying

down peasants to their land (as in feudal Europe). In conditions of larger commodity production, however, the very same other factors may lead to a centralised collection of rent/surplus (e.g., as land-revenue), so that the peasant is unable to escape exploitation wherever he is (e.g., Mughal India).²⁸ On the face of it, the first suggests a more developed form of private property, but the latter might well represent a higher stage of evolution since it represents a greater advance in commodity production. Which of the two forms is theoretically nearer capitalism; and is the latter form 'feudal' at all?

Indeed, in such circumstances the difficulty of reducing the number of systems of class-exploitation to *three*, becomes obvious. The Mughal-Indian system, for example, could, by identifying feudalism with serfdom and then stretching the significance of the term serfdom to include all kinds of compulsion upon the peasant, be designated semi-feudal by Dobb's definition of feudalism;²⁹ but it would not be such by Sweezy's (serfdom, and "a system of production for use").³⁰ The first course would result in making the significance of the term feudal so broad that almost *any* pre-capitalistic system (including even the classic slave society, contain as it did large elements of peasant cultivation), could conceivably qualify for it.

The flexibility in the use of the term feudal not having been attained by the term slavery, Marxists with 'the best of intentions' have yet failed often to locate the slave society which should have been found during the youth of every civilization. In China its period has been relegated to remote antiquity.³¹ In India its existence (not of slavery, of course, but slave society) has altogether been denied.³² Even those who still argue for the set pattern, appear ready to omit the stage of slavery as a necessary stage of development, and so modify the pattern to P-F-C. Such a modification would, however, have the absurd result that for most countries feudalism would simply become synonymous with the entire pre-capitalist past, and deprive us of the ability to trace significant changes in class relations over time.

Finally, there is the question whether every link in the standard European chain P-S-F-C should be regarded as repre-

²⁸ Cf. my *Agrarian System of Mughal India*, Bombay, 1963, for the description of such a system.

²⁹ *Studies in the Development of Capitalism*, p. 35.

³⁰ *The Transition from Feudalism to Capitalism—A Symposium*, London, 1954, p. 2 and *passim*.

³¹ Mao Tse-tung, *Selected Works*, London, 1954, III, p. 74.

³² Kosambi, *An Introduction to the Study of Indian History*, Bombay, 1956, p. 10 and *passim*.

senting the highest possible stage of social evolution in the contemporary world. For example, should the society out of which capitalism developed be seen as the most advanced in its time?³³ A moment's reflection would suggest that this is by no means certain. China today is a Socialist country, a full social epoch ahead of the United States; but this by no means implies that the old Chinese society before 1949 was more advanced than, or even at level with, the American society at the time. China was able to transform itself into a Socialist country in the 20th century, not because its economy had itself previously evolved into capitalism, but because the development of capitalism had already taken place in other parts of the world.³⁴ Similarly, if European feudalism generated capitalism, it was possible that a decisive role was played in the initial stage of the transition by certain critical technological inventions from China (such as compass, paper, printing press and gunpowder).³⁵ By itself feudal Europe would have been as powerless or as slow to discover these inventions, as old China would have been to develop capitalism through its own contradictions. It is probable that both in respect of technology and scale of commodity production, the China of Marco Polo's day was far ahead of feudal Europe. We must therefore reject as unhistorical (and undialectical) the assumption that every society at the highest stage of development would inevitably, of itself, reach the next higher stage. In fact we should look rather for alternating progress and recession in the evolution of each society, in relation to the general advance on the world scale.

It is, therefore, certain that P-S-F-C cannot contain in its chain all the primitive and class societies that have existed; nor can there be any universal order of succession, ensuring that a society akin in some respects to feudalism must always have succeeded one akin to slavery, and not *vice versa*. Of course, the chain in each country must end in capitalism (or colonialism, i.e., the subjugation of a pre-capitalist economy by an external capitalist economy), since capitalism based on machine industry succeeded in overcoming all geographical barriers and so became a universal system of exploitation. There is, on the other hand, no reason to believe that P-S-F was the standard path of the most advanced societies before the rise of capitalism. The materialist conception

of history need not necessarily prescribe a set universal periodisation, since what it essentially does is to formulate an analytical method for the study of the development of class societies. Whether the path traversed in a particular country was P-S-F-C or P-S-F-C or P-F-S-C or P-X-Y-Z-C, where C represents capitalism/colonial stage, does not affect the essentials of the Marxist conception at all.³⁶ The crucial thing is the definition of principal contradictions (i.e., class contradictions) in a society, the marking out of factors responsible for intensifying them, and the delineation of the shaping of the social order, when a particular contradiction is resolved. It is possible that release from the set P-S-F-C pattern may lead Marxists to apply themselves better to this task, since they would no longer be obliged to look for the same 'fundamental laws of the epoch' (a favourite Soviet term), or the same 'prime mover' as premised for the supposedly corresponding European Epoch.

III

An analysis which proceeds directly from the essentials of Marxism, without any mechanical copying or compromises with liberal views, is therefore called for, though it would naturally impose quite a heavy responsibility on Marxist historians. As matters stand, when the results of individual Marxist studies on various aspects of Indian history are put together, then, in spite of their authors being unconscious in most cases of the need to eschew the set periodisation, the P-S-F-C pattern is seen clearly to be inapplicable.³⁷

In the absence of adequate evidence, it is impossible to say whether the Indus Civilization was or was not a slave society. Interpretations of the early Indo-Aryan society too are rather speculative, although the forms of private land ownership,

³⁶ No exception can be taken when Hobsbawm says (without detailed justification, however) that "the general theory of historical materialism requires only that there should be a succession of modes of production, though not necessarily any particular modes, and perhaps not in any particular predetermined order". (*Pre-Capitalist Economic Formations*, 19-20.) Hobsbawm's own qualifying remarks show that he would assume capitalism to be the last mode of production in the chain of succession before socialism.

³⁷ The following summary of Marxist work reproduces in part the one given by me in the *Times Literary Supplement*, London, July 28, 1966, and is based on the more extended summaries in *Seminar* 39 (Past and Present) and in *Enquiry*, N. S., II, 3, pp. 21-75 ("Social Distribution of Landed Property in pre-British India"), where full references will be found.

³³ Cf. Goldelie's paean of praise for European feudalism and its superiority over every other system for precisely this reason (*Enquiry*, N. S., II, 3, p. 95).

³⁴ Cf. Mao Tse-tung, *op. cit.*, 77-82.

³⁵ J. Needham, *Science and Civilization in China*, IV, 2, Cambridge, 1965, pp. 6-8.

peasant cultivation and agrarian slavery are all met with. Kosambi assigns the formation of the characteristic Indian village society to the period after the Mauryas; and internal developments in this society, according to him, led to the formation of a 'feudal' order. R. S. Sharma too has seen in the period 400-1200 A.D. increasing similarities with European feudalism, owing to the presence of serfdom and decentralised polity.

But in the period after 1200 these similarities disappear. The essential elements of the structure of society of Mughal India (16th and 17th centuries) that have been brought out are, briefly, considerable stratification within the peasantry; a superior rural class (the *zamindars*) holding property-rights over a relatively minor share in the peasants' surplus; the bulk of the surplus, collected as land revenue by a small ruling class formed by the King's officials (*jagirdars*). The principal contradiction therefore lay between the King's bureaucracy and the peasantry. A large urban market existed, depending upon the expenditure of the nobles and their military contingents. The organization of commercial credit, insurance and rudimentary deposit-banking remind us of conditions in Renaissance Europe.

It would hardly make sense to treat this as part of the same epoch as the "feudal" society of the earlier millenium. Nor can one affirm that simply because of extensive commodity production (and thus a certain degree of monetization) capitalist conditions were maturing within this society. (Cf. the views of Antanova and Pavlov.) One must remember Marx's warning that capitalism as a mode of production (requiring the separation of the wage-labourer from his tools) is, historically, an antithesis of merchant-capitalism.³⁸

A more careful approach would also prevent opportunistic appraisals. From seeing 17th century India as containing potentialities of capitalistic development, it is the next step to detect the rise of nationalities, and then to acclaim a chief like Shivaji as a peasant leader and the national hero of the Maratha people.³⁹ Such concessions to chauvinism are wrong on both counts: they are absolutely unhistorical and they serve ultimately as grist to the reactionary mill.

What Marxist historians should first and foremost concentrate on is surely a study of the class-struggles. The 17th century, for example, contains extensive evidence of peasant revolts, and it is of utmost importance to analyse the basic factors which gave

rise to them (e.g., the revenue demand), to study the role the *zamindars* played in inciting or suppressing them, and to trace their course and further development (where these were formally successful).⁴⁰

Another sphere in which Marxists have to be pioneers is the study of technological development. Since we insist on the close connexion between the means of production and the relations of production, we are greatly handicapped by the absence of proper work in this field.

In spite of considerable work done on Marxist lines, our paths are still difficult and full of obstructions. This is due to a variety of causes: the primitive stage of development of modern historiography in India; the deep colouring put on all secondary work by national chauvinism and reactionary ideas; the increasing domination of revisionism over such foreign Marxist historiography, especially European, as we usually encounter in our professional work; and, finally, the actual isolation of most of us (like the present writer) from the class whose cause we claim to uphold.

To the degree our tasks are difficult, these are also exciting and rewarding. If we are able to base ourselves firmly on revolutionary Marxism, and steadily carry on painstaking research work, there is no reason why some day we should not break through the curtain of darkness imposed by reaction, and illumine the real history of the toiling people of India.

³⁸ *Capital*, III, Moscow, 1959, p. 322.

³⁹ Dange, S. A. and his followers have been in the vanguard in this respect. Cf. D. K. Bedekar's paper in the present volume.

⁴⁰ Comparisons with the historical significance of peasant revolts in China should prove of extreme interest. (Cf. Mao Tse-tung, *Selected Works*, III, pp. 75-76.)

The present paper is the first of a series of studies in the quest of knowledge about what had been happening to our economy and society until the British conquered us, enslaved us and along with their rule of colonial exploitation, gave us a certain orientation regarding our pre-British history. In other studies, we seek to discover and analyse the social forces and institutions that operated on our life and their impact on our forces and relations of production.

As in the present study, the sources sought for and utilised have been contemporary and near-contemporary accounts, Indian and non-Indian, cross-checked in the interest of objectivity.

The present effort is submitted to critical readers for their judgement, in order to learn from them where our facts are inadequate, partial, doubtful and wrong and where our interpretation is misplaced, fallacious or tendentious. Such criticism would be useful in enabling the writer to re-examine his own effort and correct his understanding. What is more, it may be the beginning of a meaningful dialogue between interested scholars on this vital theme, which is still being treated myopically and tendentiously, along the lines laid down by ill-informed, if not ill-intentioned, servants of the East India Company.

The writer is aware that recently much new light has been thrown on Indian social and economic conditions, during Medieval India. However, the process of revision of the present study (whose conclusions each new discovery has further confirmed) had to be stopped at some stage, if it was not to become interminable. It is therefore proposed to prepare a supplementary paper in the light of the new material thrown up by latest researches and publish it in course of time.

Among these recent researches the present writer considers the following of particular significance :

- (1) Irfan Habib : *Potentialities of Capitalist Development in Mughal India*, Journal of Economic History, March 1969.
- (2) Irfan Habib : *Technological Changes and Society—13th and 14th Centuries*, Presidential Address, Medieval India Section, Indian History Congress, Varanasi, 1969.
- (3) Irfan Habib : *The Technology and Economy of Mughal India*, The Dev Raj Chandra Memorial Lectures, Delhi, 1970 (Mimeographed).
- (4) Hameeda Khatoon Naqvi : *Rebellions During the Reign of Akbar*, Medieval India a miscellany, Vol. II, Aligarh.
- (5) Hameeda Khatoon Naqvi : *Urbanisation and Urban Centres under the Great Mughals*, An Essay in Interpretation, Indian Institute of Advanced Study, Simla, December 1971.
- (6) Ashin Das Gupta : *The Merchants of Surat, C 1700-1750—“Elites in South Asia”*, Edited by E. Leach and S. N. Mukherji, Cambridge University Press, 1970.
- (7) A. I. Chicherov : *Indian Economic Development in the 16th-18th Centuries*, Moscow, 1971.
- (8) Hiroshi Fukazawa : *A note on the Corvée System (Veth-begar) in the 18th Century Maratha Kingdom*, Hitotsubashi Journal of Economics, Vol. 11, No. 2, February 1971, pp. 1-10.

I

Marx's View of Indian History*

Marx's characterisation of pre-British Indian social history is well-known. In brief, it meant that whereas European history was characterised by four successive stages of economic forma-

* The present study owes its genesis to the numerous discussions I have been having with my wife, Dr. Hameeda Khatoon Naqvi, over more than a decade, from whose deep knowledge of Indian and European history, I have greatly benefited. I have freely drawn upon her researches in particular her book *Cities and Industries in Upper India 1556-1803*, Asia Publishing House, 1968, for material, specially those dealing with the medieval cities, on which she has done pioneering work, unearthing sources hitherto altogether unknown. While I acknowledge my debt of gratitude to her, I must, however, mention that she does not necessarily subscribe to my approach to history or the method I have employed and the conclusions I have reached.

It gives me pleasure to thank my colleagues, Ranjit Lahiri, A. R. Desai and S. B. Pillai, for the patient and painstaking manner in which they went through the various earlier drafts and offered valuable crit-

tions, that is, four systems of ownership of property, viz.: (1) Tribal; (2) Ancient Communal and State; (3) Feudal; and (4) Capitalist, corresponding to which developed different stages in the division of labour;¹ Indians—as also most other Asian and African countries—had until the establishment of the rule of the British or other European countries, remained stuck at the early form of the second stage and “did not arrive at landed property”,² which had already begun to arise in Europe in the later part of the communal stage.³

Thus, in Europe, history witnessed a succeeding series of growing division of labour, with increasing differentiation and specialization, bringing about a separation between agriculture, industry and trade, between village and city and alongside arose and developed, private property in land and in other means of production. However, in India (as in the entire Orient), the division of labour achieved was of an extremely primitive nature and remained more or less unchanged throughout history, and land was either communally owned or was the exclusive property of the King, with private ownership at most found in some isolated cases.⁴

This phenomenon of absence of private property in land, and the proprietary control almost exclusively the prerogative of the King, was ascribed by Marx, at the suggestion of Engels,⁵ to what he believed to be the peculiar climatic conditions in the Orient. In Europe, rainfall was adequate, land was alluvial and water sources easily accessible almost everywhere, hence private owners of land, in case of need for irrigation, could in a manner of democratic co-operation, jointly build bunds, dams and drainage and irrigation channels.⁶ In the Orient, on the other hand,

icism and suggestions, both as to the language and style, and as to errors in the ideas. If I have not always followed their advice and for the errors of style or substance that still remain, I am alone responsible.

I must also thank my colleagues, D. Rege and Sunit Bose, who kindly translated for me certain extracts of Kovalevsky and Marx's comments on them, from Russian.

Finally, I have to thank my friend Dr. K. Mathew Kurian, M.P., and his associates in the Indian School of Social Sciences, Trivandrum, for providing me with the opportunity of presenting an earlier draft to Marxist scholars at the June 1969 Conference at Trivandrum and benefiting from their comments.

¹ K. Marx and F. Engels, *The German Ideology*, Moscow, 1960, pp. 31-39.

² Engels to Marx, June 6, 1853, *On Colonialism*, Moscow, p. 278.

³ K. Marx and F. Engels, *The German Ideology*, p. 33.

⁴ K. Marx and F. Engels, *On Colonialism*, Moscow, p. 281.

⁵ *Ibid.*

⁶ K. Marx and F. Engels, *On Colonialism*, Moscow, p. 33.

most of the land was arid or covered with desert and rainfall was inadequate, with water sources for irrigation at remote distances and almost inaccessible to individual cultivators or whole villages and beyond their capacity to bear the expense of building the requisite large dams and irrigation canals and construct irrigation channels and drainage works. A strong and resourceful central authority alone could possibly undertake such projects, since it could both meet the requisite expenses, and would have the authority to divert water courses and get over the claims of owners of the lands, which may have to be submerged, as a result of the construction of the irrigation system. If the Central authority alone became the proprietor of all land it could exercise full authority on the pattern of land and water use.

Marx further held, that in order to organise orderly management of cultivated land, easily collect the royal revenues and ensure equitable and timely distribution of irrigation water supplies, which according to Engels was the very condition of the survival of these cultivating households,⁷ these households were organised in villages and groups of villages: 10; 100; 1000.⁸ And these villages were believed to have been organised on a communal basis, where each household was allotted specified pieces of land, which were periodically redistributed in order to ensure maintenance of equity. Each village was more or less autonomous so far as its internal functioning was concerned, with its own headman and other officials—maintained at common expense and common service personnel, who served all the households and were paid in kind at harvest time, besides having been allotted land for growing their own food. To ensure the smooth continuity of this system, a built-in institution of hereditary castes was established, in some remote past, which on the one hand, made social mobility unfeasible and on the other, assured secure livelihood for every household.

The absence of private property, in any case, of the feudal type, precluded the rise of classes and hence class conflicts were unknown. Thus what resulted was a three-fold phenomenon, viz.:

(1) A stable social equilibrium came into existence and was maintained through the ages, with no external occurrence, invasions, wars, rise and fall of dynasties, allowed to disturb it, except perhaps, for a while, when and if an army passed through the village in times of war or if war or some inefficient government at the centre, caused a neglect of the water supply for irrigation.

⁷ K. Marx and F. Engels, *Selected Correspondence*, Moscow, 1965, p. 82.

⁸ K. Marx and F. Engels, *On Colonialism*, p. 281.

If population grew beyond the capacity of the village land to succour them, new waste lands were broken and new settlements were established, exactly on the same pattern as the parent villages.

(2) The economy and division of labour remained stationary, generation after generation carrying on the same way of life, plying the same trades, producing the same output, maintaining the same combination of agriculture and industry, as their earliest ancestors had done, with hardly any knowledge of, or contact with life outside their respective rural habitats. The absence of classes and class struggles which in Europe had proved to be the motive force of development, because of the contradictions between the productive forces and relations of production,⁹ did not admit of any technological advance in the Orient.

(3) A few cities that arose, were rather irrelevant to those self-sufficient village communities, since they were by no means units of industrial production, except for the King and his household, the nobility and Government employees, the army, and for export, which was believed to be confined to luxury items, small bulk and high value. These cities and even the large capital towns, were essentially camp towns, sustained by the army and the Court and its entourage, their population and prosperity depending upon the pendency of the stay of these patrons.

Then came the British and the gradual disintegration of these ancient village communities, disrupting the social equilibrium by the British neglect of the irrigation works—the very condition of the functioning and survival of agriculture and these republics—and eventually by introducing the two types of private property in land—the Zamindari and the Ryotwari.

Thus, with the exogenous establishment of the desideratum of private property in land, the hitherto absent element of dynamics was injected into the Indian society. Along with the modern technical and administrative system—including faster means of transport and communication, education and newspapers, etc., the country and its people were set on the path of modern capitalist development, without, of course, the British wanting anything of the kind to happen.

All this no doubt involved and in fact was meant to destroy the very fabric of Indian productive system, so that British Industrial products—particularly, textiles—could find a lucrative market in India and Britain could secure from Indian agriculture, at monosponic cheap rates, food grain and even more, raw cotton

and other raw materials. This caused untold miseries on the Indian people, like unemployment, famines and pestilence.

However, Marx was convinced that, in essence, notwithstanding all this loss and sufferings for the Indians, the British policies were playing a definitely progressive role.

(1) Thus in June 1853, in a letter to Engels, Marx had declared : “England, it is true, in causing a social revolution in Hindusthan, was actuated by the vilest interests, and was stupid in her manner of enforcing them. But that is not the question. The question is: Can mankind fulfil its destiny without a fundamental revolution in the social state of Asia? If not, whatever may have been the crimes of England, she was the unconscious tool of history in bringing about that revolution.”¹⁰

(2) A month later, in an article in July 1853, Marx said : “England has to fulfil a double mission in India : one destructive, the other regenerating—the annihilation of Asiatic Society ; and the laying of the material foundations of Western Society in Asia.”¹¹

The question if India could have possibly taken to the dynamic path of Western society by herself, if the British had not conquered her was disposed of by Marx with the following observation :

“These family-communities were based on domestic industry, in that peculiar combination of hand-weaving, hand-spinning and hand-tilling agriculture which gave them self-supporting power. English interference having placed the spinner in Lancashire and the weaver in Bengal, or sweeping away both Hindu spinner and weaver, dissolved these small semi-barbarian, semi-civilized communities, by blowing up their economical basis, and thus produced the greatest and to speak the truth, *the only social revolution overheard of in Asia.*”¹²

Referring to the character of the village communities, Marx said :

“I do not think any one could imagine a more solid foundation for stagnant Asiatic despotism. And however much the English may have hibernicized the country, the breaking up of these stereotyped primitive forms was a *sine qua non* for Europeanization. Alone, the tax-gatherer was not the man to achieve this. The destruction of their archaic industry was necessary to deprive the villages of their self-supporting character.”¹³

¹⁰ K. Marx, ‘The Future Results of the British Rule in India’, London, Friday, July 22, 1853, *New York Herald Tribune*, August, 1853.

¹¹ K. Marx and F. Engels, *On Colonialism*, Moscow, p. 37.

¹² K. Marx and F. Engels, *On Colonialism*, Moscow, p. 36.

¹³ *Op. cit.*, p. 280.

Regarding the alternative to British conquest Marx was equally forthright :

"If we know nothing of the past history of Hindusthan, would there not be the one great and incontestable fact, that even at this moment India is held in English thralldom by an Indian army maintained at the cost of India? India, then, could not escape the fate of being conquered, and the whole of her past history, if it be anything, is the history of the successive conquests she has undergone. Indian society has no history at all, at least no known history, what we call its history, is but the history of the successive intruders who founded their empires on the basis of that unresisting and unchanging society. *The question, therefore, is not whether the English had a right to conquer India, but whether we are to prefer India conquered by the Turk, by the Persian, by the Russian, to India conquered by the British.*"¹⁴

II

The Great Debate

For a long time, Marxists continued to make their own assessment of Indian (and Asian) pre-British past, on the basis of the views of Marx. At any rate, we have no knowledge of Marx's analysis having ever been questioned. It was a datum, hence it was, perhaps, not considered necessary to examine it, in the light of new material on Indian history and its social institutions, during the ancient and medieval periods, discovered and published, with or without commentaries, since Marx and Engels had last touched upon the subject. Thus, Lenin himself is said to have made the following note in his 'Conspectus'.

"The 'Key' to Oriental customs is the absence of private ownership of land."

"All land is the property of the head of the State."

"Asiatic villages are self-contained, self-sufficient (natural economy), constitute the basis of Asiatic customs and public works of the central Government."¹⁵

It appears however that in 1930-31, quite a warm controversy suddenly erupted among Soviet Orientologists on the Marxian view at Tbilist and Leningard.¹⁶ The debate would seem to have

¹⁴ *Op. cit.*, p. 76.

¹⁵ Quoted by Y. Varga from Lenin's *Conspectus of the correspondence of K. Marx and F. Engels, 1844-1883*, Russian Edition, Moscow, 1959, pp. 260-263.

¹⁶ Y. Varga, *Politico-Economic Problems of Capitalism*, Moscow, 1960, p. 336.

been triggered off by the appearance of G. Dubrovsky's book entitled *Concerning the Essence of the Asiatic Mode of Production*, etc. in 1929 in which the author is said to have criticised the concept of the Asiatic Mode of Production and held that India and other Asian countries did have private property in land and did develop feudalism, although here feudalism was without the European type of serfdom.¹⁷

Varga refers to two of the leading participants in the debate, M. Godes and E. Iolk, besides Dubrovsky and mentions two symposia, containing the reports of the discussions at Tbilist (*On the Asiatic Mode of Production* published in 1930) and Leningrad (Society of Marxist Orientologists, "Discussion About the Asiatic Mode of Production", Moscow-Leningrad, 1931).

Although, we are not told anything about the arguments advanced by the defenders of the Asiatic Mode Concept, Varga informs us that "At the discussions held in Tbilist and Leningrad in 1930-31, the existence of Asiatic Mode of Production was denied and it was transformed into an "Asiatic Variety of Feudalism".¹⁸

We are further told by Varga that "The editors' note to the Tbilist discussions reads: 'The development of the Asian countries has throughout history been highly individualistic. In a certain sense this peculiarity has created a special structure of feudalism which may be called the Asiatic Mode of Production.'"¹⁹

Again, according to Varga, an identical formulation can be found in M. Godes's concluding remarks at the Leningrad discussion. "We prefer to speak of a peculiar feudalism in the Orient, and not of an Asiatic Mode of Production."²⁰

It further appears that some of the participants sought to deny that Marx really considered Asiatic Mode of Production to be a specific type of economic formation different from Feudalism since Varga quotes M. Godes as declaring: "...It is about time to stop discussions on whether Marx recognised the Asiatic Mode of Production as a specific social formation. We must not close

¹⁷ Varga also mentioned Academician V. Struve, who according to the former had "denied the existence of an Asiatic Mode of Production" in 1928 and during the 1931 discussions in Leningrad said that the Asiatic Mode of Production Existence in Egypt "up to the Roman Epoch, when Roman rule introduced a different formation" and again shifted his opinion and declared that there was no Asiatic mode in Egypt, but it was a slave-owning society. Earlier Struve is said to have held that "Egyptian peasant—in many cases held land but did not own it".

¹⁸ Y. Varga, *Op. cit.*, p. 336.

¹⁹ *Ibid.*

²⁰ *Ibid.*

our eyes to Marx's indisputable statements, even if we do not share his view on the Asiatic Mode of Production".

Godes held that in Marx's time many facts about the Oriental countries were unknown and that Marx, who was not familiar with Lewis H. Morgan's research, therefore advanced the existence of the Asiatic Mode of Production as a working hypothesis. "Marx . . . had, on the one hand an idea of primeval relations, on the other . . . of the system of ancient society with its sharp class differentiations, the gap in Marx's understanding of the historical process compelled him to look for the missing link."²¹

Finally, Godes is reported to have asserted that "The Asiatic Mode of Production is nothing but Feudalism".²² Thus, in sum the conclusion reached seems to have been:

(a) Asian countries did arrive at private property in land and the feudalism did develop there, though in a somewhat different form, that is without the European type of serfdom.

(b) Marx's conception was wrong since at the time he was writing, facts regarding actual developments in Asia, were very inadequately known.

It is interesting to note Varga's reaction to this debate, some thirty years after the event.

Firstly, Varga held that Marx and Engels clearly visualised the Asiatic Mode, as a specific form of social formation, fundamentally different from feudalism and that they continued to hold this view right upto the end and "nowhere do we find an indication that they doubted the existence of a special Asiatic Mode of Production".²³

However, Varga was of the opinion, that: (a) Marx's interchangeable use of the terms 'Asiatic' and 'Oriental', showed that he included vast areas of Africa also in this connection. (b) Marx did not extend the concept to the whole of Asia, but only to those regions where the rainfall was insufficient for agricultural production.²⁴

Secondly, he was of the view that the critics of Marx were taking an un-Marxian and unrealistic attitude of flying in face of facts, which clearly prove the actual existence of an Asiatic Mode of Production. Here, he cites three points of circumstantial evidence in defence of the concept, viz.:

(1) The measure for land in China, in the 'mu', which is one sixteenth of a hectare, indicating that population concentrated

on small irrigated strips of land, since rainfall was scarce.

(2) The archaeologists' discovery of towns in African and Asian deserts show that a strong central power, building and controlling the water system and of the type associated by Marx with the Asiatic Mode of Production, must have existed, otherwise how could such towns with large populations and huge temples and pyramids, etc., grow up in the middle of the desert and the extension of the desert may have occurred long after these towns were built. Changes in the course of rivers and climates and advancing of deserts with de-forestation is not unknown in history.

(3) That, in Oriental languages, according to Engels, there is no word for 'landlord', could be possible only because of the existence of the Asiatic Mode of Production.²⁵ The present writer hopes to examine Varga's circumstantial evidence, among other things including the impression of Engels regarding the supposed absence of an equivalent in Oriental languages for the term language in a larger work on the Asiatic Mode of Production, on which he is currently engaged.

Varga at the same time concedes that "It is difficult to find documentary evidence to prove the existence of the Asiatic Mode of Production".²⁶ It was perhaps this realization that led Varga to write in the penultimate paras of his book:

"The problem can be reduced to the following: did recent research prove Marx's 'hypothesis' wrong or not? Did an Asiatic Mode of Production exist at any time in History? I do not consider myself competent enough to give a *categorical* (emphasis Varga's own) answer to these questions."²⁷

Until the fifties, Marxist scholars, at least outside the Soviet Union, seem to have continued to accept the concept, entirely uncritically.

However, we notice in some of them an ambivalent tendency, as we shall see later.

A certain group of Marxists which is unable to agree with the concept of Asiatic Mode of Production and has tried to establish that Marx had either abandoned the concept after the seventies or at any rate had begun to reconsider the concept in the light of new material, presented by, among others, the famous Russian Sociologist M. M. Kovalevsky.²⁸

²⁵ Y. Varga, *Op. cit.*, p. 347.

²⁶ *Ibid.*

²⁷ Y. Varga, *Op. cit.*, p. 351.

²⁸ To name only two prominent scholars, we may mention—

(1) Daniel Thorner, 'Marx on India', *Contributions to Indian Sociology*, Paris, No. IX, December, 1966, p. 66, and

²¹ Y. Varga, *Op. cit.*, p. 350.

²² Y. Varga, *Op. cit.*, p. 351.

²³ Y. Varga, *Op. cit.*, p. 335.

²⁴ *Ibid.*

There is yet another group, which has begun to question the validity of Marx's concept and deny the historical existence of anything like his type of Asiatic Mode as basically different from feudalism.

This group while insisting that Marx did use the concept Asiatic Mode as something basically different from feudalism, however feels that in the light of recent researches and new material now available, there is clearly the need for a serious and objective re-examination of the validity of Marx's concept, with its connotations.

At least one scholar questions the sanctity of the very sequence of social formations as formulated by Marx and Engels and holds that they could never have meant the sequential order to be taken literally. This scholar has pleaded for a more realistic re-examination of historical material in order that specific stages of social formations in time and space may be objectively determined. He would like consideration to be given to the possibility of reversals of earlier types of social formations even after a higher type had already developed.

Thus the great Debate has begun and may be expected to be joined by ever more Marxists, more specially by Marxist scholars of the Asian, African and North and South American countries.

III

Did Marx Abandon or Change His Views

The present writer is of the view that:

(1) Marx and Engels were categorical and altogether unambiguous in their thesis that the Oriental societies did not evolve private property in land, and feudal formation did not develop there, and what did come into existence and was perpetuated, causing stagnation in economy and social institutions, was the Asiatic Mode of Production, with a system of built-in equilibrium which remained more or less stable and undisturbed due to the absence of antagonistic classes and class struggle.

(2) There is no basis in the claim that either Marx or Engels, at any stage abandoned their concept of Asiatic Mode or that their views were beginning to be re-considered by themselves.

Thus, it is on record that Marx, in his reply to Vera Zasulich (the first of the four drafts), 1881—just two years before his death—reiterated the same views as formulated in his oft-quoted articles and letters of the fifties.

(2) Irfan Habib, 'Problems of Marxist Historical Analysis', *Enquiry*, Delhi, Monsoon, 1969, pp. 51-56.

Further, Engels in *Anti-Duhring* published in 1878, a book, each of whose chapters, according to Engels was seen by Marx,²⁹ who actually contributed the section on History, repeated the same view.

And we find that in all the subsequent editions of this book, during Engels' life time, including the 1894 edition, these passages not only remain unaltered, but there is no hint regarding any doubt having arisen on points noted in them.

Again, the same strain is found in Volume III of *Capital*.³⁰ While it is true that the basic ideas of this book were available in Marx's manuscript already more or less completed, Engels while editing the text made a few emendations when he published it several years after the death of Marx and this may be said to explain the continued stress on Asiatic Mode, since the text was drafted while Marx was still of his views of the fifties. However, the matter is really not that simple. For we have seen that in the course of his editing *Capital*, or introducing new editions of any of the writings of Marx, or a joint work, after the death of Marx, Engels was always careful to mention either in his Prefaces or in the notes, the changes that their views or even terminology may have undergone, either since the work was originally published, or since it was written, in case of an unpublished work. Here it should suffice to recall his "Labour and Labour Power" distinction in *Capital*³¹ and "all written history" for "all history" in the Communist Manifesto.³²

Hence, if there were the slightest shift in their views on the Asiatic Mode Concept—particularly regarding India and China, with which countries Marx and Engels were most concerned, from among the Oriental countries, Engels would certainly have made some, even though only a passing reference to it.

Finally, so far as the likelihood of a reconsideration of Marx's views, as a result of his study of Kovalevsky's book *Communal Landholdings: The Causes, Character and Outcome of Its Disintegration*, published in 1878 and discussions with the author, is concerned, the excerpts of Marx's critique of Kovalevsky, available to us, clearly indicate Marx's rejection of the Russian Sociologist's suggestion that three of the four main criteria of Germano-Roman feudalism were to be found in India, which

²⁹ F. Engels, *Anti-Duhring*, Moscow, 1969, pp. 214-15, 217 and 366.

³⁰ K. Marx, *Capital*, Vol. III, Moscow, 1959, pp. 328-29.

³¹ K. Marx, *Wage, Labour, Capital*, Introduction by F. Engels, 1891, p. 71, in Vol. I of Marx-Engels Selected Works, Moscow, 1962.

³² K. Marx and F. Engels, *Manifesto of the Communist Party*, Foreign Languages Publishing House, Moscow, p. 47, Footnote h.

ought therefore to be regarded as feudal.³³ In the words of Marx "Kovalevsky forgets among other things serfdom, which is not of substantial importance in India. (Moreover, as for *individual role* of feudal lords as *protectors* not only of unfree but of free 'peasants . . . this is unimportant in India except for the Wakuf—Estates devoted to religious purposes')." Nor do we find that "poetry of the soil" so characteristic of Roman-German feudalism (cf. Maurer) in India, any more than in Rome. In India the land is nowhere *noble* in such a way as to be, e.g., inalienable to non-members of the noble class (roturiers). [We propose to examine this dictum in a separate study.]

Thus, nothing in the hitherto available evidence, admits the possibility of any change in the views of Marx and/or Engels about the nature of the Asiatic Mode, much less a substantive reconsideration or abandonment of their earlier understanding.

IV

Evidence Re-examined

The next question is, were Marx and Engels justified, even on the basis of evidence available in their day, to come to the conclusion that the character of social formation in Asia and specially in India, throughout history, or at any rate, since the arrival and conquest by the Muslims, was fundamentally different from the various types of feudal social formations,—the classical English and French one, or even the Romano-Germanic variant.

Let us now look into the authorities, Marx and Engels seem to have utilised as their source of knowledge regarding the history of the Asiatic or Oriental peoples and their economic, and social institutions.

(1) We shall begin with Bernier.

As is well-known, Marx and Engels were greatly impressed by Bernier's description of Indian conditions as he saw or understood them.

Now Marx found two significant features of Indian economy in Bernier, viz.,

(a) The King is the sole and only proprietor of all the land in the Kingdom; and

(b) The towns in India, including even the capital cities like Delhi and Agra, were properly speaking nothing but military

camps, only a little better and more conveniently situated than in the open country.

It is surprising that Marx and Engels failed to note two significant things in Bernier's account, one seriously qualifying the sweeping generalisation regarding the royal ownership of land and the other contradicting the characterisation of the Indian cities like Delhi and Agra.

(a) Regarding the first point, we find Bernier, while again and again, reiterating his generalisation, also refers to literally scores of hereditary Rajas, within and without the empire, with their own territories, where they reigned supreme, either as tributaries of the empire, or as independent rulers, seeking to maintain their sovereignty and not unoften, as in the eastern parts, even making forays in the imperial domains. These Rajas were, according to Bernier, of such importance that they could afford to raise and maintain huge armies and the Mughals were obliged to treat them with caution and care and endeavoured to win their support in their campaigns of conquest, suppression of revolts and even during wars of imperial succession.

It is obvious that these Rajas, occupying large territories, could not have possibly acquired their huge resources, without being overlords of the agricultural lands in their estates, able to draw resources from these lands, in their own rights.

Besides, Bernier, has made no reference to any law or even a Qazi's (judge) verdict, indicating even by implication, that possession of land was necessarily, in all cases or even generally non-hereditary in the case of persons, other than government officials, who received temporary jagirs, in lieu of their emoluments, or that they were subject to escheat on the death of the holders, with or without an issue to succeed them.

Indeed, Bernier does not mention one single instance of escheat having actually occurred, during the five years of his stay in the Empire, most of which time he seems to have lived in the capital town of Delhi, in the service of Fazil Khan, the Chief Steward of the Royal Household, where he must have been close enough to the court circles to hear about the property of any rich person being escheated to the King, on the death of the former, if any such incident had taken place.

The solitary case he mentions is that of the reign of Shah Jahan, in which, on the complaint of the son of a merchant, attached to the court, the Emperor sent for the widow and ordered her to pay one lakh rupees to himself and fifty thousand to her son, out of the two lakhs, her husband had left behind him. Now, according to Bernier, the widow told the Emperor :

" . . . my son hath some reason to demand of me the goods of

³³ Quoted in Eric J. Hobsbawm, K. Marx, *Pre-Capitalist Economic Formations*, New World Paper Back Edition, International Publishers, New York, 1969, p. 58.

his father, as being of his and my flesh and blood and therefore our heir ; but I would gladly know what kindred, is your majesty to my deceased husband to be his heir. . . ."³⁴

Bernier finally reports that the Emperor :

"Commanded . . . that nothing should be asked of her."³⁵

If anything, this incident is an evidence to the contrary. Here was the widow of a rich court employee—and merchant—money-lender—, not seeking to deny that her husband had left a lot of cash behind, clearly not afraid that there was any natural right of the Emperor to the property left by her late husband. And when she questions the basis of the Emperor's claim—even of a share—the Emperor or any Minister is unable to remind her of any law or convention, that the property of a court employee, automatically passes on to the Emperor. Besides, it would seem to point to a convention that normally, the children of a person were regarded as his heirs on his death. Recall the widow's remark ". . . being of his and my flesh and blood and therefore our heir. . . ."

In this connection, another thing is noteworthy, Marx and Engels had concluded that the absence of private property in land and the King's ownership of all land was due to the aridity of the soil and the need for large irrigation works. However, Bernier, in his letter to the French Minister Colbert stated :

" . . . You may please take notice, that of that vast extent of land, there are large countries that are very fertile, and some of them to that degree (for example, the whole of the great Kingdom of Bangala) that they exceed those of Egypt, not only upon the account of the abundance of rice, corn, and all other things necessary for life, but also upon the score of all those commodities so considerable, which Egypt is destitute of, as silks, cottons, indigo and so many others, sufficiently related by authors."

"Moreover, that of these same countries there are many that are well enough peopled and cultivated. . . ."³⁶

And neither anywhere in the letter nor elsewhere in the main text of the book, do we find any reference to the lack of rain or the dependence on irrigation, the creation and maintenance of large irrigation works by the State. Further, when we recall that during the early part of Bernier's visit, the war of succession was going on, causing undoubted chaos, which could not have left unaffected normal services like the major irrigation channels,

³⁴ Bernier, *The History of the Late Revolution of the Empire of the Great Mogul*, to which is added a Letter to the Lord Colbert, London, 1671, pp. 147-48.

³⁵ *Ibid.*

³⁶ Bernier, *Op. cit.*, pp. 3-4.

(if they were really built and maintained by the State through its officers) adversely reacting on cultivation and production, supply and prices of agricultural commodities, it is surprising that our travellers should neither have noticed it, nor considered it important enough to record it.

Even when he mentions that "among these vast tracts of land there is much, which is nothing but sand and sterile mountains",³⁷ Bernier does not tell us that they are cultivated with the help of water supplied by State canals etc. On the contrary, he said that they are " . . . little tilled or peopled. . . ."³⁸

Indeed, far from any paucity of rains in India, we are told by Bernier, in his Ninth letter to Monsieur de Merneilles : ". . . in the month of July, when the heats are most violent, rains begin regularly to fall, which continuing for three months, together, do temper the earth, and render it very fruitful. . . ."³⁹

Regarding Bengal, or Bengala as he calls it, after the then current usage in India—Bernier says in the same letter : ". . . in Bengala these rains are pouring down for four months, and sometimes continue for eight days and nights together without intermission. . . ."⁴⁰ It is revealing that when Bernier tells us that "there are also some years, in which they (the rains) are not so plentiful as in others ; insomuch that two years together it did almost not rain at all ; . . ."⁴¹ he does not mention that in these years, the State irrigation system provided water for cultivation. Actually what he says is that ". . . this caused much sickness and great famine. . . ."⁴²

It is thus clear, that Bernier neither noticed any normal need for State water supply for cultivation, nor its general organisation by the State, so much so, that in years of complete or even partial drought, crops failed and scarcity and epidemics resulted.

Therefore, the thesis of climatic foundation of absence of private property in land, and the consequential natural development of institution of ownership of all land by the King, assumed by Marx and Engels would not seem to hold water.

As a matter of fact, where he does refer to irrigation works, Bernier talks of "ditches and channels for the course of water",⁴³ which are apparently maintained by the peasants themselves and that when the peasants neglect them, they are no more effective.

³⁷ Bernier, *Op. cit.*, p. 7.

³⁸ *Ibid.*

³⁹ Bernier, *Trans.*, p. 401.

⁴⁰ Bernier, *Op. cit.*, pp. 401-2.

⁴¹ *Ibid.*

⁴² *Ibid.*

⁴³ Bernier, *The History*, Tom. II, p. 34.

Let us now turn to the second point—the character of Indian cities.

While Bernier refers to several towns, he gives us particulars mainly of Delhi and Agra.

As seen above, our traveller tells us that :

(i) these were merely large military camps ;
(ii) their population depended for its livelihood on the army ;
and

(iii) the entire or almost the entire population was forced to accompany the army, whenever the King took to the field, implying that the cities were practically deserted, in between two military campaigns of the King.

We shall examine these points separately.

(i) If we were to carefully read the enthusiastic and exhaustive description of Delhi—and a little less so of Agra—their location, area, population and its composition—public buildings, the Fort, the style of architecture, the pattern of construction—with his defence of the pattern on the basis of their being just as good and convenient as the Parisian homes, in the background of Indian climate,—the quarters of the soldiers and the town poor, the roads and avenues and the bazars and their wares etc.,⁴⁴ giving an impression of permanence and solidity, it is difficult to escape the feeling that Bernier was being metaphorical in his characterisation. Moreover, Bernier may have had his French patrons in mind, because this characterisation occurs in the course of his comparing Delhi and Agra with Paris, besides his natural sense of pride in Paris.

(ii) So far as the population of Delhi is concerned, Bernier had estimated that “. . . if there be not altogether so much people in Delhi as in Paris, at least there wants not much of it.”⁴⁵

Now, although Bernier does not give us any specific estimate of Delhi's population, we may safely assume that the population of Delhi after 1638, could not have been less than that of pre-1638 Agra, that is, between 5 lakh to 6 lakh people.⁴⁶

It goes without saying, that in a capital town like Delhi—specially chosen by Shah Jahan to serve in place of Agra—the Royal court would be the fulcrum round which the civic life would revolve. The principal and primary consuming classes would be the Royal household, alongwith its numerous servitors and armed guards etc., and their dependents, the nobles and others attached to the Court and their families and servants, the

soldiers and their dependents and finally the clerks etc., employed in various government offices and establishments.

The producing and servicing classes would be the artisans and craftsmen, the shopkeepers, merchants, bankers, cartmen, washermen, physicians and surgeons, the veterinary doctors, the teachers, the apothecaries, the watermen, the watchmen, the building workers, blacksmiths, carpenters, stone workers, painters etc., who would naturally depend for their livelihood on the primary consumers.

Thus our author says that “. . . all the inhabitants of the town, living upon the Court and the army. . . .”⁴⁷

Here the question is, how big was the army stationed in Delhi and what was its likely weight in the aggregate demand on the services of the producing and servicing classes. For this would give us a means to judge the degree of exodus of the latter classes caused by the departure of the army.

At one place, Bernier mentions that the army following Aurangzeb on his way to Kashmir in 1664, consisted of 1 lakh horsemen, 70 field pieces, drawn by 20 teams of oxen and some elephants and 3 lakh to 4 lakh soldiers and camp followers.

However, Bernier does not say that this whole army was drawn from Delhi. Thus, we may assume it, that this figure does not necessarily represent the strength of the army normally stationed in Delhi.

Our assumption is confirmed by Bernier's own statement at one place that 35,000 horsemen were stationed in Delhi and by another that the entire number of horsemen in the army, *in the field*, amounted to 1 lakh. Thus, 65,000 of these 1 lakh must have been drawn from outside Delhi, most of them contributed by the tributary chieftains and Jagirdars etc.

Now, according to Bernier, each of these horsemen was followed by servitors of one kind or the other. Hence, whereas 35,000 Delhi-based horsemen would draw another 70,000 camp followers drawn from Delhi, no less than 1.3 lakh non-Delhi men would be accompanying the non-Delhi horsemen, if we assume two persons accompanying each horseman.

This would bring the combined total of Delhi and non-Delhi horsemen and their camp followers to 3 lakh of which 1 lakh would come from Delhi and 2 lakh from outside.

Now we have 1 lakh of the 4 lakh—the upper limit—left. And these may be presumed to consist of foot-soldiers.

Obviously all these could not have been drawn from Delhi, since the Chieftains were expected to supply both horsemen and

⁴⁴ Bernier, *Travels*, pp. 221-40.

⁴⁵ Bernier, *Op. cit.*, pp. 264-65.

⁴⁶ See footnote 72.

⁴⁷ Bernier, p. 357.

⁴⁸ *Op. cit.*, pp. 356-57.

foot-soldiers. And if we were to apply the same proportion as in the case of horsemen, the Delhi-based soldiers would number 35,000, while those coming from outside would be of the order of 65,000.

Thus in all, the number of soldiers, both horsemen and footmen, together with the camp followers drawn from Delhi would total up to 1.4 lakh.

This would still leave about 3.5 lakh to 4.5 lakh of the normal population of Delhi, staying on in Delhi.

If we were to take Bernier literally, and assume that 35,000 horsemen and 35,000 foot soldiers totalled the entire strength of the army normally stationed in Delhi, its withdrawal should mean acute distress in the population left behind—3.5 lakh to 4.5 lakh persons exclusively dependent on the army. And yet, we are not told by Bernier that starvation or serious distress occurred in Delhi, during the several month-long absence of the Emperor and the army.

We may thus conclude that Bernier's characterisation was metaphorical, otherwise an untenable situation faces us.

This for Delhi. How about Agra? This city had ceased to be the capital in 1638. And yet, just as Delhi has been reported to have continued to be populous even after Akbar chose Agra for his capital, contemporary accounts tell us that Agra, even after the Emperor Shah Jahan's moving out to the new Capital at Delhi still continued to flourish, as noticed by Tavernier and Bernier, among many European travellers and a number of Indian contemporaries, as late as 1685.

While it is true that for general strategic reasons and also because Shah Jahan was imprisoned there, discretion must have led to the stationing of an adequate armed force at Agra, as to how large this force was, we are not told. In any case, the force in Agra should have been considerably smaller than at Delhi and must have been stationed there permanently, although of course its personnel may have been changing.

However, it is surprising to learn that such a huge population was able to continue and evidently sustain itself, even after the Court had shifted to Delhi and the city could no longer live off the Court, with the armed forces themselves being considerably reduced.

Perhaps, what actually happened was that in these two cities, as also in the hundreds of others big, middling and small ones, with populations ranging from a few thousand to 2 to 3 lakh however they might have been founded, as a historian has recently discovered, gradually an element of economic viability was introduced, firstly by the consumer demands of the rising

population and secondly by the thousands of artisans and trades people who carried on their occupations to meet these demands and in turn received their own sustenance from these consumers and trades people who carried their goods outside and themselves became consumers of each other's products. Dr. Hameeda Naqvi gives a graphic account of the scores of economically active towns, apart from the five principal capital and commercial cities—Delhi, Lahore, Agra, Benaras and Patna.⁴⁹

It would thus be seen that the picture that emerges from the account of Bernier, as a whole, is substantially different from the one gleaned by Marx and Engels presumably from the same source.

For example, Bernier reports plenty of rainfall in all, except some areas and mentions neither the dependence of Indian agriculture on large irrigation works, nor notes their existence.*

Indeed, where he does refer to artificial irrigation, he mentions only "ditches and channels", maintained by the peasants themselves, which, as is well known, themselves depend on rains.

Thus the very *raison d'être* of the absence of private ownership of land is brought into question.

Again, Bernier does not even *en passant* refer to any kind of isolated village communities, in any part of India he visited—Gujarat, Agra, Delhi, Punjab, Bengal and some areas in South India. Nor does he mention having heard of the system of periodic redistribution of land.

With regard to the cities, his characterisation has been shown to have been no more than metaphorical and an inclination to accept it as realistic has, on closer examination proved to be contradicted by his assumptions.

That Marx and Engels missed this picture could only be due to their really not having been able to study the full text of Bernier's account, including his letters to Colbert and others.

2. Let us now consider the Parliamentary Reports.

Now, it is obvious that by the Parliamentary Reports, in this context, Marx is referring to the Fifth Report of 1812, since it is here, that the passages made so famous by him, are contained.

Here again, the question arises, did Marx study this Report at first hand, or had he based himself on only this particular part, reproduced somewhere else? This doubt arises in our mind,

⁴⁹ H. K. Naqvi, *Cities and Industries in Upper India, 1556-1803*, Asia Publishing House, 1968.

* No doubt, some canals were constructed by official agencies. But these were few in number. In the main, irrigation, where necessary, was carried on by private, individual, or collective effort, through wells and tanks, etc.

since a careful scrutiny of the text of the Fifth Report reveals, that it contains a large number of other accounts, regarding the agrarian systems of the regions below the Vindhyas, which completely contradict the impression created by the one quoted by Marx, or at any rate makes one conclude, that this passage at best, reflected the conditions in only some parts of the region and by no means represented the typical form of agrarian relations in South India.

Our doubt is further confirmed when we observe that while Marx neither directly quotes the passage from the Fifth Report, nor in fact even mentions it by name, exactly the same passage is found in two sources, which he specifically refers to, viz.:

(i) *Historical Sketches of the South India*, 1810-17, Vol. I, by Lieut.-Col. Mark Wilkes; and

(ii) *Modern India and Its Government* by Sir George Campbell.

It may be noted that in the Fifth Report, this passage occurs on pp. 85-86, as a part of the "Northern Circars Report of the Committee of Circuit and Memoirs of Mr. W. Oram delivered to Government in the years 1786 and 1787".⁵⁰

It is significant that no other report of the District Collectors and the Fifth Report is essentially a collection of District Collectors' Reports, makes any reference to similar pattern of landholding, anywhere else.

As a matter of fact, the other reports in the Fifth Report contain descriptions, which clearly point to the existence of private ownership of land, with full proprietary rights, including the right of sale, etc.

For instance, the Principal Collector of Canara writing on May 31, 1800, after referring to the existence of private property in land and incidence of land sales, etc., had the following to say regarding the land system in the Vijayanagar Empire:

"The alienation of land, by sale or otherwise was unrestricted. Nothing but flight or sale, or non-payment of rent, could take it from the owner. If he absconds with balance standing against him, it was transferred to another person; but if he or his heirs returned, at ever so distant period, it was restored. . . . No crime in the proprietor could extinguish the right of the heirs to the succession. . . ."⁵¹

We are further told that the owner was free even to rent out part of his land.⁵²

Yet another report mentions that Tipoo Sultan had changed the

⁵⁰ Select Committee, *Fifth Report*, House of Commons, 1812, pp. 25-6, 807-8 and 885-6.

⁵¹ *Ibid.*

⁵² *Ibid.*

joint assessment system into a system of individual assessment of each landholder.⁵³

It is significant that Marx does not refer to any of these other reports, which contain unambiguous reference to private ownership of land,

It would thus appear that either Marx took the village community quotation from Campbell, or if he took it from Wilkes' book, which seems more likely, Wilkes too did not take note of the other—contrary—reports included in the Fifth Report. That Marx perhaps never consulted the Fifth Report, in original, seems to be further confirmed by the fact, that neither in *Capital*, nor in any of his other writings or letters, do we find a single reference to this source.

The fact that among the Parliamentary Reports included in the Bibliography appended to *Capital*, Volume I, there is no mention of the Fifth Report of the Select Committee of the House of Commons, published in 1812 is significant. And the passage of one of the Collector's reports quoted by Marx on page 358 of *Capital*, Vol. I, Moscow edition, refers to the source as Lieut.-Col. Mark Wilks: *Historical Sketches of the South of India*, 1810-17, Vol. I, pp. 118-20. It may thus be considered conclusive, that Marx and Engels did not consult the 1812 Report directly, and therefore were unaware of the wide variations in land relations and property systems, discovered by other collectors, elsewhere in South India.

However, it even seems doubtful, if Marx was able to study Campbell's book, on which he appears to base his own views regarding North India, in full, or even the earlier four chapters, where the writer has recounted certain relevant aspects of Indian agrarian system, particularly in upper India, with which he was familiar.

This doubt arises from the fact that, while Campbell reproduces parts of Fifth Report and himself refers to the existence of "Village Communities" in North Western India, ". . . about the Upper Sutlej, and East and West, to the Jumna on one side and far into the Punjab, on the other . . ."⁵⁴ he really does not mean by village community, the same thing as Marx does.

Campbell divided the village communities into two types, viz.:

(a) the simple or the aristocratic type, whose headman or "Potail" is an employee of the Imperial Government, as are the Karkuns (or Karnam) and Qanunge, etc., who perform various functions in connection with the assessment of rent and its

⁵³ *Ibid.*

⁵⁴ George Campbell, *Op. cit.*, p. 80.

realization, etc., which according to Campbell, have been reported to be found in South; and

(b) the 'strong' or 'democratic' type, which is jointly owned by members of a tribe or sub-tribe or clan and, whose internal affairs are supervised and adjudicated by a body of punches, who also negotiate with the Government officials, regarding the revenue charge on the village and are responsible for allocating, collecting and discharging the dues of the State.⁵⁵

Further, there is a significant departure from the concept of Marx.

First, we are told of the possibility of differentiation among the landholders by holding size. For instance, Campbell says: ". . . Claim to the office (Punchship) is considered to consist in a large stake in the village and personal fitness. A clever, well-spoken man *who has a good share of land* (emphasis ours) and is the head of a number of relatives and friends, becomes one of the Punch. . . ."⁵⁶

Second, the existence of "the accountant and banker and mercantile inhabitants" who were, according to Campbell, regarded rather as "allies than subjects, for though they have no direct voice in the management, they are courted as moneyed men, who increase the prosperity of the community, and with whom all have transactions". "*Money is power in all communities.*"⁵⁷ (Emphasis ours.)

Here, we find a pattern of division of labour and the presence of money economy and commodity production and trade, which Marx had ruled out.

And there is absolutely no reference to self-sufficiency or production only for direct consumption or isolation of these communities, since he tells us, ". . . From them (the moneyed men) advances, etc. are received, they take all the grain and credit at market price, and generally the revenue is paid through them".⁵⁸

One can clearly see the emergence of commodity production, even in agriculture, in this cash nexus between the traders and the producers.

Then we have the singular feature of the rest of the "inhabitants—carpenters, blacksmiths, priests, etc., etc." (presumably including the weaver, oilman, sugarmaker, etc., S. N.) "and the large number *who do everything laborious except actual agriculture, and are sometimes employed to assist in that*—all these

are classed as 'Kameens' or inferiors, and receive an annual allowance of grain for their services. . . ."⁵⁹

Thus, here we have the elements of a class of craftsmen and labourers, with no land of their own, which are missing Marx's model, and no reference to any unity of crafts with agriculture, as posited by Marx, except as occasional agricultural labourers.

Again, we discover the desire and no doubt the effort could not have been absent—to seek prosperity, in the recognition of the power of money, and respect for the moneyed men, in the background of the then existing stage of commodity production.

Campbell tells us of, the existence of the right of alienation of land and to sale, even to a stranger though not without the consent of fellow landowners. However, sale to members of the village community seems to have been freely permitted.⁶⁰

Campbell further tells us how in the rest of North India, among other areas, the Zamindari system had already been existent, at least since the Mughal period, or had spread during the period of civil wars and anarchy since the death of Aurangzeb, together with the growth of differentiation between landlords and tenants⁶¹ and presumably among the peasants themselves.

And yet Marx did not note any of these features reported by Campbell.

Finally, we have the testimony of Campbell that "in the plains the roads are always in dry weather practicable for carts", though he adds "always excruciatingly bad . . ." since he could not find that "they ever metalled their road. . . ."⁶²

This too Marx seems to have entirely missed.

If Marx and Engels had only read the travel accounts of even a few of the scores of European travellers and merchants who had recorded their experience, often ranging over several decades and covering large parts of the country, published in the early years of the 19th century by Purchas and others in England, they would have been able to roughly and more realistically reconstruct Indian social and economic conditions in different periods, from the 16th to the 18th centuries.

They would have learnt that—

(1) All-India centralised empires have existed very infrequently and few of them survived even two centuries.

(2) Behind the apparent might and magnificence of the imperial houses stood the hereditary feudal chiefs who exercised immense power, by virtue of the surplus they extracted from

⁵⁵ George Campbell, *Op. cit.*, p. 84.

⁵⁶ George Campbell, *Op. cit.*, pp. 88-9.

⁵⁷ *Op. cit.*, p. 90.

⁵⁸ *Op. cit.*, p. 91.

⁵⁹ *Op. cit.*, p. 94.

⁶⁰ Campbell, *Op. cit.*, p. 94.

⁶¹ *Ibid.*

⁶² *Op. cit.*, p. 34.

the peasants of their estates and the private armies that they maintained. They would have also found out that the standing army of the king was very modest—considering the vastness of the empire and that he depended on the feudal chiefs and jagirdars for men to enable him to conduct his military campaigns effectively.

(3) They would have learnt of the growth of internal trade in the country and a vast and effective net-work of communication by road and water. To take one example, according to Pelsaert, the Agra traders could learn quickly, from their agents in Golconda about the despatch of spices, etc., from Masulipatam to Agra—a distance of over 1,500 miles—and were able to take advantage of this knowledge, making huge profits, while the European traders were left guessing,⁶³ and suffered losses.

(4) They would have been told that India was by no means a more or less rural country, but that it had numerous cities of varying sizes, many of which were economically active and even viable,⁶⁴ and the ratio of urban to total population was considerable.

Thus a contemporary of Akbar tells us that there were as many as 120 big cities and 3,200 townships (Qasbas), each having from 100 to 1,000 villages under it.⁶⁵

One European traveller considered Lahore as “second to none either in Asia or Europe”.⁶⁶

In 1615, we find Coryat declaring Lahore to be “one of the largest cities of the whole universe”.⁶⁷

English travellers considered early 17th century Ahmedabad to be as big as London, with its suburbs.⁶⁸

Again, in early 17th century Patna and Masulipatam were estimated by European visitors to contain 2 lakh people each.⁶⁹

Adverting to Agra we find that a foreign traveller's account recorded between 1583 and 1586, that both Agra and Fatehpur Sikri were larger than London.⁷⁰ Salbanks confirms a few years later, the estimation of Fatehpur Sikri.⁷¹

Further, while Father Xavier writing between 1593 and 1617, when Agra was still the imperial capital estimated the city to

have a population of 5 to 6 lakhs,⁷² another foreign traveller Manrique two years after the transfer of capital to Delhi, estimated the Agra population to be of the order of 6.6 lakh.⁷³ Both Tavernier⁷⁴ and Bernier⁷⁵ writing during the second half of the seventeenth century, almost two decades after the shift of the capital from Agra, adjudged the city to be still considerable in area and populousness. This is further corroborated by the accounts of Amal Saleh Kamboh⁷⁶ and Brahman.⁷⁷ In 1685 almost half a century after the transfer of capital from Agra, Sajan Rai gives a similar impression of Agra.⁷⁸

This would make patent the autonomous viability of Agra and no doubt of many other cities and towns, notwithstanding the absence or withdrawal of direct court or army patronage.

(5) It would have come to their knowledge that as far back as 1600, in Mughal Hindustan alone (from Lahore to Patna) as many as 32 urban centres manufactured cotton cloth in large quantities and were famous for their high quality and low prices.⁷⁹

(6) They would have been able to see that a class of affluent merchants, shippers, bankers and money-lenders was rapidly growing, engaging in internal and external trade, money-lending, banking and bills of exchange transactions.⁸⁰

(7) They would have also learnt about the recurring conflict between the traders and the feudal lords and officials on the issue of the exaction of transit dues on merchandise, notwithstanding frequent Firmans of the Emperor against such practices.⁸¹

(8) It would have come to their knowledge that numerous peasant uprisings occurred in India—even in the vicinity of the Capitals—Agra and Delhi—rather than there being a picture of a passive peasant population.⁸²

⁷² J. Xavier, *Letters*, 1593-1617, J. A. S. of Bengal, New Series, Vol. XXIII, 1927, p. 121.

⁷³ Ralph Fitch, *Narrations*, London, 1899, pp. 97-8.

⁷⁴ Tavernier, 1, 105.

⁷⁵ Bernier, 1, 284, 285.

⁷⁶ Amal Saleh Kamboh, *Bahar-i-Sukhan*, 161a, I.O.L. Etne, 2090 (quoted from H. K. Naqvi, *Op. cit.*, p. 19).

⁷⁷ Chandra Bhan Brahman, Chahar Chaman Brahman, 56b-57a, I.O.L. Etne, 2093 (quoted from H. K. Naqvi, *Op. cit.*, p. 19).

⁷⁸ Sajan Rai, *Khulasat-ut-Tawarikh*, translated by J. N. Sarkar, Calcutta, 1920, p. 23.

⁷⁹ H. K. Naqvi, *Op. cit.*, p. 136.

⁸⁰ H. K. Naqvi, *Op. cit.*, p. 41-4.

⁸¹ H. K. Naqvi, *Op. cit.*, pp. 204, 227, 272 and 280.

⁸² Irfan Habib, *The Agrarian System of Mughal Area*, 1566-1707, Asia Publishing House, 1963, pp. 333, 337-8, 340-41 and 346.

⁶³ F. Pelsaert, *Jahangir's India*, Cambridge, 1925, p. 22.

⁶⁴ H. K. Naqvi, *Op. cit.*, pp. 9, 134.

⁶⁵ Nizamuddin Ahmad Bakhshi, *Tabaqat-i-Akbari*, Vol. III, Asiatic Society, Calcutta, 1936, pp. 545-46.

⁶⁶ F. S. T. Monserrate, *The Commentary*, Oxford, 1922, p. 159.

⁶⁷ W. Foster, *Early Travels*, London, 1927, p. 243.

⁶⁸ Foster, *Op. cit.*, p. 206.

⁶⁹ Foster, *Op. cit.*, p. 140.

⁷⁰ Ralph Fitch, *Narrations*, London, 1899, pp. 97-8.

⁷¹ Purchas, *His Pilgrims*, London, 1626, Vol. III, p. 84.

They would have learnt of large-scale desertions of discontented peasants particularly in the Doaba area.⁸³

(9) They would have also seen that a national market along with the extension of the empire was developing, that the circulation of money was growing and that most of land tax was paid, not in kind, but in cash, thereby further expanding the trading transactions. Thus monetisation of the economy and accumulation of merchant and moneylending capital was growing apace and so was agricultural and non-agricultural production.⁸⁴

(10) As a matter of fact, they would have seen that the real failure of the Mughal Emperors lay in their continuing to allow the hereditary Chieftains and Zamindars and even Jagirdars and Mansabdars to raise and maintain their own armed forces and levy taxes and transit imposts in utter disregard of the Royal decrees while the Royal army was relatively small in number.

What the foregoing would have made patent is that the Mughal administration was extremely inadequately centralised and normally at the mercy of powerful chieftains, if and when they considered it opportune to rebel or to become indifferent to the Royal commands, specially in times of widespread discontent and disturbances, not unoften directly or indirectly encouraging or even associating themselves with the uprisings.

Indeed, one can't help observing the paradox that precisely since the time, after Akbar had reconquered, extended and consolidated the Empire, with increasing population, expanding production of agriculture and industry and trade, both internal and foreign, as also with the Indian areas outside the Empire, the obvious measure to curb the economic and military power and influence of the bigger Tributary Chieftains and the Jagirdars and Mansabdars was not undertaken. Instead of putting them on salaries in cash and abolishing the Jagirdari and drastically reforming the feudal systems—to build direct links with peasants and the traders and come to their aid against the harassment and exactions of the chiefs and jagirdars and thus win them over as their allies against the recalcitrant feudal elements and thereby encourage production and trade and acquire additional strength and broaden the social base of the monarchy and disbanding private armies, strengthening the Royal army substantially, the monarchy relied more and more on the feudatories and Jagirdars, etc., seeking to strengthen itself by the illusory means of playing one chief against another and frequently changing the Jagirdars—a game which was bound to be self-defeating, in the long run.

⁸³ Irfan Habib, *Ibid.*

⁸⁴ Irfan Habib, *Ibid.*

This is what the Tudors did after the Wars of Roses ended in their victory. But their near contemporaries in India failed to read the signs of the times and alienated themselves from both the feudal and quasi-feudal (Jagirdars) elements and their victims—the peasant as also from the rising new force of craftsmen and traders, whose weight in the economy was rising, but who were far from gaining any effective political protection, notwithstanding the imperial desire and repeated pronouncements and decrees.

All this Marx and Engels failed to observe. Thus, rather than formulate issues for historical investigation into the factors behind this paradox and its probable relationship with social and economic developments in India or lack of them, they arrived at definitive conclusions on the basis of the largely mythical original sin—the Indian climate.

Of course, it may well be, as has been argued by Hameeda Naqvi, in a hitherto unpublished study, that the empire was too large and conditions in different national regions too varied, as a result of uneven developments, caused by geographical and historical factors, for such a centralisation to be feasible and effective. Attempts to enforce economic and administrative policies and laws, originally framed to suit the specific conditions of the heartland of the empire—Lahore to Patna, actually adversely affected the economies of distant provinces, which before annexation were in a flourishing state, under local rulers who, though some of them had foreign blood in their veins, had settled down in these areas as virtual natives.

Indeed, this opens up an extremely interesting line of speculation and investigation into the nature of conflicts between the centre of heartland Lahore to Patna-based imperial system and the interests of the provinces like Gujarat, Maharashtra (Khandesh, Berar, etc.), Punjab, Sind and Pakhtoonland, which were—and are—distinct regions and the relation between this conflict and the subsequent revolts in these areas against the empire, leading to the rise of Mahratta power under Shivaji—and the Sikhs in the Punjab.

V

The Debate Must Continue

That Marx and Engels could not come to a correct view of Indian social history was perhaps unavoidable, in the circumstances under which they lived and functioned, specially due to the stresses and pressures on their time and energy, though their interest never slackened.

However, it is now incumbent on Marxist scholars and parti-

shades of ideologies, rightists as well as leftists. The events of February 1969, in Bombay, have brought the issue to an ugly focus. The discussions on the activities of the 'Shiva-Sena', in the Parliament, revealed how regional interests and passions could mask real issues and distort historical facts.

In this paper, we will try to present an assessment of the situation, in which Shivaji established an independent Maratha kingdom. In this context, we will assess the theories put forward regarding Shivaji's achievements.

The question which one may firstly ask is : 'How do we explain the popular support and loyalty of the common man in Maharashtra that Shivaji could secure in his efforts ?'

This question has been answered by Indian scholars, particularly Maratha scholars, in different ways. Their arguments can be classified according to the *emphasis* that is placed on one or the other factor in the then prevailing historical situation. The classification is as follows :

- (a) Emphasis on the emergence of a *national consciousness*. This is Justice Ranade's thesis.¹
- (b) Emphasis on the revolutionary changes effected by Shivaji in *property-relations in land*, in favour of the peasants. This is S. A. Dange's thesis.²
- (c) Emphasis on the establishment of a *Hindu Kingdom*, in opposition to the alien Muslim (Mughal) imperial rule. This is V. D. Savarkar's thesis.³

It cannot be denied that the three factors, mentioned above, are potentially or incipiently present in the historical situation, and piecemeal evidence can be adduced in favour of the emphasis on one or the other of these factors. What one needs to do, however, by way of an objective historical interpretation, is to deny none of these factors, but to present a truthful *total balanced picture*, in which each factor is given only its due importance.

If we go through the massive literature in Marathi that has grown round the Shivaji-theme, we find that the emphasis has wavered between : (1) affirmation of a secular national (all-India) consciousness and, alternatively, affirmation of a secular

nationality (i.e. Maratha) consciousness ; (2) affirmation of religious (i.e. Hindu) national consciousness. All these trends have existed, in a confused and undifferentiated amalgam, from the beginning and persist even today. Ranade, as we have already noted, emphasized the secular national factor, but he was followed by others who emphasized the factor of Hindu resurgence. The factor of land-reforms, favouring the peasants, was emphasized by S. A. Dange and Lalji Pendse,⁴ who, as Marxists, brought into focus the economic situation.

Before we proceed to discuss separately each one of these trends, mentioned above, we would anticipate the discussion and affirm that the *total picture* is different from what is conjured up by placing the emphasis on any one of the three factors, mentioned above.

Historical achievements of Shivaji and the secret of his popularity lay in his great personality as a benevolent ruler, who secured the affection, support and loyalty of Maratha people against alien conquerors ; Shivaji gave an efficient, incorruptible administration to the people. He was not a bigoted intolerant Hindu ruler. Moreover, he was a born military leader and as such could secure the loyalty of his generals and soldiers.

It is clear, therefore, that the pictures conjured up by Ranade, Dange and Savarkar are lopsided and present distortions which prevent the emergence of an objective total picture of Shivaji.

The contemporary 'cult' is only a consequence of the fact that Maratha historians did not succeed in building up an objective image of Shivaji, on the basis of a realistic appraisal of the economic, social and political factors of the situation ; and also because they interpolated their contemporary ideas, biases and 'needs' into the historical past.

Let us now discuss the three interpretations, outlined at the outset. We will first take up Dange's Marxist thesis, because a critique of the same will provide a suitable background for discussion of the other two theses.

Dange puts forward the following points :

(1) Shivaji destroyed the economic power of *deshmukhs*, who were comparable to the feudal lords in Europe. He, thus, revolutionized property-relations in land, and conferred ownership of land on the cultivating peasants.

(2) He created a non-hereditary bureaucracy, and, thus established a direct relationship between the monarchical state and the peasantry.

¹ M. G. Ranade, *Rise of The Maratha Power* and other Essays, and K. T. Telang, *Gleanings from Maratha Chronicles*, University of Bombay, March 1961, p. 20.

² S. A. Dange, *The achievements of Shivaji* in 'Kranti' (Marathi) of 17 February 1938.

³ V. D. Savarkar, *Hindu Pad-Padashahi* (English), Second Edition. Manohar Grantha Mala, Poona 2, November 1942 (First Edition 1925). pp. 3-5, 14, 286.

⁴ Pendse, Lalji, *Dharma ki Kranti* (Marathi), published by author, September 1942, and *Shivrayache Athavave Svarup* (Marathi), in *Yugantar* weekly, April 1958.

(3) He was leading a peasant-revolution and his army was a peasant-army. Dange contrasts this volunteer-army with the mercenary armies of the Mughal emperor and of the Bijapur Sultan.

Now, this whole argument is based on a wrong assumption about the role of *deshmukhs* in Maharashtra. Dange thinks that *deshmukhs* were a class of landlords, *intermediaries* between the king and the cultivating peasants. The real situation can be summarized as follows :

(a) *deshmukh* literally means the leader (*mukha*) of the land (*desh*). He was the hereditary leader of the group of village-communities, which comprised his *deshmukhi*. Each village, in turn, had a hereditary *patil* or headman.

Both the *deshmukh* and the *patil* were not officers of the king. (The revenue officer of the king was the *Kamavisdar*, whose office was, in theory at least, not hereditary.)

It may be noted here that the *nadagauda* in Karnatak is the exact counterpart of *deshmukh* in Maharashtra. The Persian word *vatan* means *desh*, and it appears that the term *vatandar* was coined to include all *traditional hereditary village functionaries* from the *deshmukh* down to the *mahar* (who was virtually a slave of the village community). In Maharashtra, the *vatandars* are all these village functionaries, who are neither appointed nor paid by the king.

(b) The *deshmukh* did not have property-rights in or title to all the land in his *deshmukhi* area. He owned some land like other peasants, who owned lands in their villages. He was not, however, a landlord, in the sense in which landlords were owners of land in feudal Europe. (Landlordism, created by the British in Bengal, was a new phenomenon in India. This was, therefore, described by Marx as Irelandization of Bengal.)

Here, we may add that the persons who held *inams* or *jagirs*, secured from the king or emperor, were also not landlords in the European feudal sense. They shared the surplus extracted from the peasants by the ruler. In this sense, they were exploiters of the peasants, but not as owners of land in the European feudal system.

The *vatandars* were also living on the surplus of peasant-production. But, their exactions were limited by tradition. The king and his *jagirdars* exacted whatever they could by force. The *vatandars* could not do so. By way of compensation, one may say, the *vatandars* (even the lowliest *Mahar vatandar*) enjoyed a traditional honour and status in the village society. There are records to prove that this status (of a *deshmukh*) was coveted by a ruling monarch (like Sahu, the grandson of Shivaji), and

was prized more than the status of a *jagirdar* or king.⁵

Since the two categories—*vatandars* and *jagirdars*—are not clearly and distinctly understood, and both are lumped together and equated with European feudal land-owners, we have tried to show how they differ from each other in essential functions and status.

Let us also deal with the term *zamindar*. This term was used to describe the new class of landlords created by the British. But, what are the antecedents of the term ?

Dr. Irfan Habib has discussed the role of the *zamindars* in his paper "Potentialities of Capitalist development in the economy of Mughal India".⁶ He has said that "village was the usual unit of assessment" (p. 15) and the *zamindar* was "responsible for the collection of the land-revenue", which was claimed by the king, (p. 16). The *zamindar's* claims on the surplus of peasant "were of an independent origin", (p. 16). So far, the *zamindar* seems to be having the same role as that of the *deshmukh*.

But, Dr. Habib has pointed out that due to monetization and excessive pressure of land-revenue, the *zamindar* could alter the "substance" of his "economic right" and also could "expand the area under that right", (p. 16). In other words, the *zamindar* tends to become an "intermediary" and *zamindari* rights tend to become a "fully saleable commodity", (p. 16).

It is true that the *zamindar's* claims on the peasants are in the nature of exactions from the surplus of peasant production. But, are we to consider that these exactions are in the nature of rent expropriated by landlords, under conditions obtaining in feudal Europe ? Alternatively, do we put the *zamindars* into the class of *jagirdars*, who formed the nobility under the Mughal Emperor ?

I think that Dr. Habib is not asserting either of the two propositions outlined above. He is of the opinion that, *zamindars* remained a class by themselves, whose claims on the peasants had only a traditional origin, and he would agree that the claims did not originate nor were they sanctioned by the imperial power. The claims were limited by the framework of the traditional village community. It is necessary, therefore, to clearly differentiate between the *zamindars* and *jagirdars*.

This alone can explain why the peasant revolts of the Jats,

⁵ S. N. Joshi, *Marathekaleen Samaj-darshan* (Marathi), Anath Vidyarthi Griha Prakashan, Poona 2, 1960, pp. 1-15, 33-68, 220-229.

⁶ This paper was submitted in cyclostyled form, to the International Economic History Congress, in 1968. It was kindly made available to me by Dr. Amalendu Guha, my colleague in the Gokhale Institute of Politics and Economics.

Marathas and others were not *against* the *zamindars*, but very often *under* their leadership, as is affirmed by Dr. Habib. The revolts were usually against the unlimited rapacity of the *jagirdars* or emperors.

Here, we can make a general observation that Dr. Habib's analysis of the north-Indian situation brings into focus the effects of monetization in agrarian economy of the Mughal period. In this respect, the region of Shivaji's activities presents a different picture. Monetization had not then developed in this region, as was the case in the North and this is evidenced by the meagre size of towns like Poona, Satara, etc., compared to the size of towns like Agra in the North. This is further evidenced by the fact that no trading caste, like Jains, Vaishyas and Khatri in the North, was indigenous in Maharashtra, in the period of Shivaji's activities, and even later.

The *deshmukh's* role in agrarian society, therefore, remained what it was since centuries of static village economy.

We shall now return to the problem of the *deshmukhs* in Maharashtra. Were the Maratha peasants in revolt *against* the *deshmukhs* under the leadership of Shivaji? Did Shivaji destroy the system of *vatandari* or *deshmukhi*, in order to free the peasant from the oppression of these *deshmukhs*?

The facts of history do not point to such a situation. Shivaji was himself the son of a very powerful *jahgirdar*, Shahaji. Shahaji was a brave and resourceful general and had almost acquired the position of a king-maker in the chaotic conditions of the Deccan Bahamani Sultanates. Shahaji's political power and experience served as a foundation for the independent kingdom, which Shivaji later succeeded in establishing.

Shivaji secured the support and loyalty of the class of *deshmukhs* and punished only a few individual *deshmukhs*, who opposed his authority. (It is true that a few *deshmukhs* became rapacious, exceeding their legitimate traditional status and function. Shivaji punished the excesses in such marginal cases.) There is no evidence to show that Shivaji had any intention of abolishing the class of *deshmukhs*. In fact, just as no emperor, king or *jagirdar* in Indian history had created this class, none ever planned to abolish it.⁷

It is to Shivaji's credit that he tried to fix the land-revenue assessment, on a village, on the basis of actual classification and measurement of cultivated land. This was, however, not a revolutionary measure, and was only an administrative action, on

the lines of similar actions taken earlier by Todarmal and Malikambar. Dadoji Kondadev whom Shahaji had appointed at Poona as the elderly adviser to young Shivaji, was following his predecessors, in introducing these revenue reforms, which later Shivaji continued in his *jagir*.

Arising out of the above, one may justifiably say that Shivaji's successful revolt against the Mughal emperor was the achievement of a military and administrative genius; it is, moreover, the success of a man of high character and courage. But, in terms of class-situation, he was born in and belonged to the nobility (*jagirdar* class) and led the *deshmukhs* and peasants of Maharashtra, as their natural leader, against a non-indigenous ruler. He did not visualize, attempt or achieve any changes in the relation of the classes or changes in property-relations in land.

Shivaji did not create anew any system of non-hereditary bureaucracy. The Mughals, and even the earlier Hindu kings and emperors, had their own bureaucracies. The rulers, Mughals as well as Hindus, selected men of ability for posts in the civil and military services, often irrespective of their caste status and religious creed. Usually, however, a ruler used to favour persons belonging to his own racial or religious group, and used to confer favour on others out of necessity and diplomatic considerations. Shivaji followed the same pattern. He also gave *inams*, which are merit awards like *jagirs*. The *jagirs* are large-scale grants of land-revenue claims over a sizeable area, while *inams* are grants of such claims over a very small area. In theory, both are only shares in the claim of the donor ruler, and both do not amount to title in lands.

Here it will be pertinent to answer the question whether the Muslim rulers in India accepted the ownership of peasants in land. Did they claim for themselves or for their *jagirdars* title to land in their domains? The answer is firmly in the negative. Dr. Kureshi has shown from evidence of Muslim law, *Aine Akabari* and from a *farman* issued by Aurangzeb, that Muslim rulers explicitly recognised the peasants' title to land. The European concept and practice of landlordism was unknown to them.

A word about the army that Shivaji commanded. There was a difference between the morale and temper of the Mughal army and that of Shivaji's army. The latter was rooted in the land and in the people of Maharashtra. But, that is not the same thing as a peasant army. Can the peasant guerillas harassing the army of Napoleon retreating from Moscow be called detachments of a peasant revolutionary army? But, their heroic

⁷ D. K. Bedekar, *Samyukta Maharashtra* (Marathi), Chitrashala Press, Poona, 1947, pp. 136-176.

guerilla action was possible only because of their rural base. Almost the same may be said of the army of Shivaji and also of the guerilla fighting for twenty years after the execution of Sambhaji, son of Shivaji. These guerillas were acting heroically with a sense of loyalty to the king and his royal House.

Now, let us take the thesis presented by those who consider that Shivaji was trying firstly, to establish an independent Hindu Kingdom in Maharashtra, and secondly, to create a basis for the establishment of a Hindu Imperial rule over India.

The thesis has to be rejected for two reasons :

(a) The weakening of the Mughal empire after Aurangzeb departed from his earlier tolerant policies, revealed the dangers of an intolerant and bigoted attitude on the part of a king, more so on the part of an emperor. Shivaji was fully conscious of this danger and of the instability of a bigoted Hindu or Muslim rule. In his letter to Aurangzeb, Shivaji offers to co-operate with him, if he were to accept and act upon the secular tolerant policies laid down by Akbar.

(b) For a number of socio-cultural reasons,⁸ [e.g. the absence of a powerful centralized Hindu (or Muslim) religious authority and organization, comparable to the Catholic Church in Europe], the Imperial or regional rulers, in India, did not envisage a *theocratic* monarchical state. The Indian State had to remain non-theocratic and tolerant. Shivaji was a deeply religious person, but as a king he followed this tradition of religious tolerance. In fact, his superiority over Aurangzeb, in this matter, shows how Shivaji had a more comprehensive insight into contemporary Indian political events and also in political traditions of this continent.

We shall now take up the views of Justice Ranade, who initiated the evaluation of the achievements of Shivaji.

Ranade's thesis could have an objective basis in the fact that Maharashtra (as constituted today in the State of Maharashtra) has certain common ecological and cultural factors, e.g. Deccan black soils, *jowar* as main food crop and Marathi as the common spoken language. But, these and other factors involved in social, religious and political history of the region, only warrant an assumption that a consciousness of nationality (or unity) existed *only potentially*.⁹ To assume that this mere possibility was turned into an actuality by Shivaji is to take a big step, and

such a step needs objective justification. One cannot here go into detailed arguments and evidence, but the present author thinks that Ranade's thesis, in this respect, cannot be held to be valid. Despite all the factors which might have contributed to the emergence of a regional (Maharashtrian) consciousness, or the sense of a "common purpose" which Ranade assumes "animated the Marathas"¹⁰ under Shivaji's leadership, one feels that such an emergence did not take place,—it remained only a potentiality as it did for centuries prior to Shivaji.

One simple argument, to refute Ranade's thesis, may be stated here. Almost all Maratha scholars, including Ranade himself and those who carried on research after him, accept that soon after Shivaji's death (1680) the Maratha power expanded in territory and strength, but lost the sense of "common purpose". By the end of the eighteenth century, Maratha power had extended vastly northward and eastward, but it was devoid of any cohesion and conscious regional or nationalistic purpose. These scholars are forced to put forward the hypothesis that Shivaji alone had achieved a miracle, which faded away soon after his death. This hypothesis raises Shivaji's image to a superhuman stature.

It will be only right to acknowledge the genius of Shivaji, as a leader of exceptional courage, insight and exemplary character ; but it would be wrong to build up an interpretation of history in which "national consciousness" emerges and fades away like a mirage.

In conclusion, it may be stated that the three interpretations discussed above cannot be validated on the basis of concrete historical evidence. In paragraph 3, we had given an outline of a "total picture" of Shivaji's achievements. One can further explain the remarks there thus : Shivaji belonged by birth and achievements to the ruling class of *jagirdars*. He successfully defied the Mughal imperial power and established an independent kingdom. As a benevolent ruler and administrator, he won the confidence of his people. He was a devout Hindu and was tolerant to non-Hindus. This non-bigoted attitude won for him the affection of Hindus, and support of Muslims. He did not effect any revolutionary or radical reforms in the field of land-tenure and maintained the system of *deshmukhs* who were the natural hereditary leaders of village-communities and peasants. His army was, like armies in those times, recruited from peasants, but was not a peasant revolutionary (guerilla) army.

Shivaji also could not and did not unite the Maratha people

¹⁰ M. G. Ranade, *Rise of the Maratha Power*, pp. 16-17.

⁸ Joseph Needham, *Science in East and West*, in *Science of Science*, Ed. Goldsmith, M. and Mackay, A., Souvenir Press, London, 1964.

⁹ On this issue, vide article by Ellen E. McDonald, "The Growth of Regional Consciousness in Maharashtra", *Indian Economic and Social History Review*, Vol. V, No. 3, September 1968, pp. 222-43.

into a nationality. The sense of commonalty, amongst the people, remained latent. (It started becoming overt and vocal only in the nineteenth century under the leadership of educated leaders like Ranade.)

In the end, one can offer a remark about certain contemporary events in Maharashtra. Apart from the activities of the Shiva Sena, which essentially has anti-democratic roots and roles to play besides deification of Shivaji, we have other phenomena which go to show that Shivaji's historical image is blurred and a cult-image is projected. A cult-image is essentially reactionary and prevents people from comprehending the material and spiritual content of a historical situation or of the achievements of a person like Shivaji. Whenever objective history remains weak it is substituted by cult-history and sinister myths like the 'Nordic myth'. The situation in our academic historical studies points to the danger of cult-histories emerging everywhere. The remedy is serious study of history in its social, economic and religious dimensions, obviating lopsided and one-sided interpretations.

6 Geography behind History : An Introduction to the Socio-Economic Study of Northeast India*

Amalendu Guha

I

Introduction

Economic history essentially relates to the human factor which widely varies from people to people and from time to time. Yet an enquiry into the physical environment—location, rainfall, relief, soils, mineral resources, natural vegetation and all that—is not altogether a fruitless exercise for its purposes, since the material culture is a product of man's action upon nature. Such an enquiry may at least enable us to arrive at some tentative statements about a country's past ; particularly so, when relevant information from usual sources are either altogether missing or inadequate.

Fringed on three sides and intersected in the middle by high mountain ranges, the north-east region of India has never been entirely cut off from the currents of historical change. In the valley of the Brahmaputra, the same civilization as that of the Indo-Gangetic plains took root in very ancient times. It was occasionally even enriched by direct or vicarious culture contacts with the Chinese civilization. Pelliot has shown that from at least the 2nd century B.C., there was a regular trade-route between

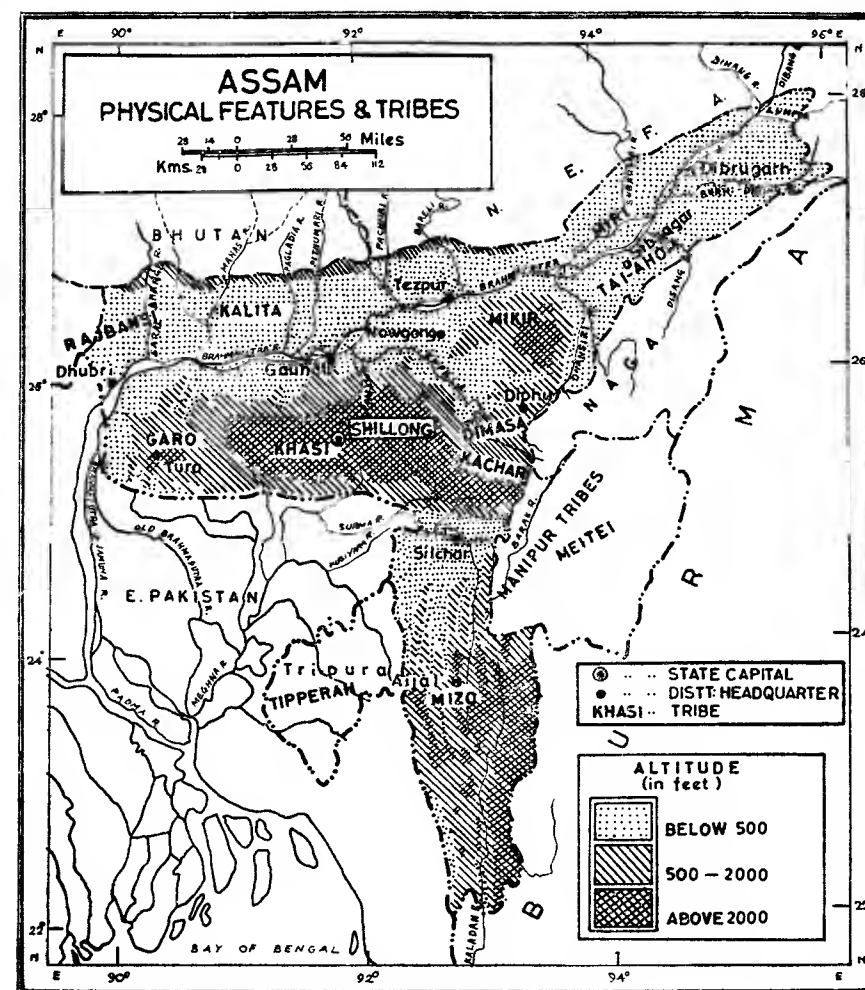
* North-east India, for purposes of this paper, includes North-East Frontier Agency, Assam, Nagaland, Meghalaya, Mizoram, Manipur and Tripura. However, the main focus is on the Brahmaputra Valley. The proportion of hilly areas in North-east India is more than 70 per cent of the total area. The total population of this region, as per 1971 Census, is 19,572,296 persons. This constitutes 3.6 per cent of the country's population.

eastern India and China through Upper Burma and Yunnan.¹

The difficulties of a hilly and swampy terrain and the consequent relative isolation from the rest of the changing world could not stop culture contacts. The knowledge of agriculture and the smelting and working of iron and other metals had reached Assam long before the Gupta Age. So numerous and extensive are the traces of former excavations for iron ores in the Khasi-Jaintia Hills that, early in the 19th century, Lt. Yule guessed them to have had occupied the population for some twenty centuries.² The Austric-speaking matriarchal Khasis, originally representing a stone-shouldered hoe-culture, are believed to have entered northeast India from West China. Their migration is believed to have had taken place around 1000-500 B.C.³ Their metallurgical knowledge appears, however, to be a later development. The fundamental change from stone-age hunting and food-gathering techniques to early iron age civilization in northeast India skipped the stage of copper and bronze.

However, because of inhibiting geographic and ethnic factors, the spread of the use of iron and iron-tipped plough in north-east India was somewhat halting, limited and uneven. Till this day it is the fire-farming (*jhum*) and the associated hoe-cultivation that dominates the hill area. In the plains, too, various forms of land-intensive shifting cultivation stubbornly persist here and there even after the substitution of the hoe by the plough many centuries back. This phenomenon cannot be adequately explained without reference to the relevant geo-physical factors and ethnology.

Notice of the Kingdom of Kamarupa in our epics and *puranas*, rock inscriptions going as far back as the fifth century, subsequent epigraphic and archaeological ruins found in the region, and above all, the predominance of Sanskrit-based languages in the plains—all these undoubtedly prove an early beginning of the process of Sanskritization in this region. Suniti Kumar Chatterjee argues that the 'Aryanization' of the ruling classes in the western part of the Assamese-Bengali area (i.e., Kamarupa) was completed as early as circa A.D. 400. According to him, the Brahmaputra valley definitely appears to have become a part of Aryan-



Map I

speaking India by A.D. 1200.⁴ But this view has to be accepted with some reservation. For, even thereafter many tribes of the valley continued to maintain their own speech, as well as their peculiar modes of cultivation, housing, funeral rites and religious beliefs. On the other hand, the Aryan way of life itself was

¹ *Bulletin de l'Ecole Francaise de l'Extrême Orient*, (1904), pp. 142 ff.

² Lt. Yule, "Notes on the Iron of the Kasia Hills for the Museum of Economic Geology", *Journal of Asiatic Society of Bengal*, II (1842), p. 853.

³ The culture of stone-shouldered hoes has been studied by A. H. Dani. *Prehistory and Protohistory of Eastern India*, (Calcutta, 1960).

⁴ Suniti Kumar Chatterjee, *The Place of Assam in the History and Civilisation of India*, (University of Gauhati, 1955), p. 35.

permeated—as *Yoginitantra* (II, 9, 13) of cira 16th century points out—with non-Aryan ways of the *Kirata* (Bodo-Kachāri) people.

The census data of 1872 and 1881 reveal that the entire hill population of Assam remained non-Hindu and preliterate, and only some one-half or so of its indigenous valley people could be designated as pure or recently-Hinduised tribes. Hence, one may presume that the bulk of the medieval population of north-east India escaped Sanskritization despite their Hinduised ruling families. The greater part of this region remained independent of—though not detached from—the successive Indian empires of the past. This political isolation that was progressively abridged only after 1826 is yet another factor of influence in the region's economic history.

In the following sections, an attempt will be made to gauge the impact of both geographic and ethnic factors on the region's medieval material culture, with particular reference to Assam.

II

The Economy of the Hill Region

The Himalayan and the Assam Ranges (nearly 90,000 sq. miles), surrounding the Brahmaputra basin on its three sides, are peopled by various tribes speaking Tibeto-Burman languages. The only exception to this are the matriarchal Khasi-Jaintia people who speak an Austric language. None of these languages had a written form until the coming of the Christian missionaries in the field. The people of Western Kameng of NEFA, however, had some two centuries ago adopted Tibetan as their written language.

The rice economy of the hill region, supplemented by food-gathering, hunting and fishing, was never self-sufficient. But the hills produced, amongst other things, cotton, long pepper, vegetables and in some areas, oranges (*sumthira*). These together with rock salt, iron and wild forest products were, from times immemorial, bartered for the surplus rice, dried fish, silk and cotton piece-goods of the plains. Hill people used to come down to the plains every winter for their barter trade or marauding raids. Some of them even settled down on the banks of the hill streams in the foothills plains for an easier living. They thus served as a link in the channel of communications between the plains and the hills. This plains-hills continuum through suc-

cessive waves of migration from hills to plains retarded the tempo of Sanskritization in the Brahmaputra Valley, despite its very early start.

Jhuming, as a form of cultivation, dominates the hill economy. Under this form, selected forest plots on hill slopes are cleared by slashing down and burning the jungles. These plots are cultivated continuously for some three years or so, and subsequently left fallow for several years. Cultivation involves hardly any tilling. Seeds are simply sown broadcast on the ashes, or are dibbled into holes with a digging-stick or a hoe—the practice varying from place to place and from tribe to tribe. The sowing may be done for mixed crops on the same plot or for crops grown separately on different plots. The practice again varies according to the local custom. *Jhuming* is thus multi-form. It involves the full and continuous utilization of a plot of land to the point of exhaustion.

The shifting cultivator has an understanding of his environment. He knows what crops grow best on what soils. He knows how many successive crops he can raise from a given plot and how many years of rest it requires thereafter. His indices of restored fertility are the vegetational phases that follow the cultivation. The *jhum* system requires, in the long run, ten to fifteen times more land to maintain a family than the wet cultivation on permanent fields. But over an year, even half-an-acre of virgin land under mixed crops might suffice for a nuclear family of five, allowing for the exchange of the surplus cotton for rice and taking into consideration the free jungle products.⁵

Shifting cultivation should be taken more as a concession to conditions of land-abundance and the character of the soils than as a 'device of barbarism'. Moreover, animal-drawn ploughs are unsuitable for hilly tracts. In Western Kameng of NEFA as in Bhutan, the plough was introduced early, under the Tibetan influence, even on high altitudes. The plough used in Bhutan in the 19th century was found even superior to that commonly used in Assam and Bengal. "The plough in use is not unlike the Bengalee plough," wrote Ashley Eden, "but the pole connecting the plough and the yoke, instead of being straight is

⁵ See the tabulated estimate by B. H. Hodgson for a Bodo peasant family of a submontane region in his paper in *Journal of the Asiatic Society of Bengal*, XVIII (1849), p. 740.

Due to an increasing population, the *jhum* cycle tends to shorten over time. Thus, it is, at present, of around 5 years' duration in the Garo Hills, 4 years' in the Khasi Hills, 5 years' in the Mizo Hills and 10 years' in the Mikir Hills. Obviously the shorter the period, the less is the productivity.

curved ; an angle is thus procured which sends the share a good depth into the ground.”⁶ But the primitive all-wood plough used by the Buddhist Sherdukpen tribe of Western Kameng in NEFA is very light and fit only for the soft soil. The plough is not unknown to the other Monpa tribes of Western Kameng as well. But the Āpātanis who carry on transplanted paddy cultivation on wet and permanent fields of the Rupa Valley in NEFA, on the other hand, do so only with hoes, and not the plough. In Meghalaya, the plough cultivation was practised around 1824⁷ only in certain parts of the Jaintia Hills. But bulls, and not bullocks, were yoked for this purpose. Barring these few exceptions, the absence of ploughs has been a general feature of the hill economy as such.

Nevertheless, permanent terrace cultivation, i.e., the cultivation of narrow, built-in land-strips on hill slopes co-existed with *jhuming* amongst advanced tribes. In this form of cultivation, the land-strips are rimmed with mud and stones so that the rain-water, or water led into them from neighbouring streams, may be retained. Hoeing is carefully done and the terraced fields tend to be permanent, hereditary property of the individuals. The terrace-cultivation is widely practised by the Āpātanis as well as the Monpas of NEFA, the Maos and the Tangkhuls of Manipur, the Angamis of Nagaland and, in recent times, by the Khasis.

Of all the hill tribes it is the Khasis whose agriculture has been traditionally the most diversified. *Jhuming* apart, they also divide up the bottoms of the valleys into little compartments by means of fairly high banks. Water is let in at will by means of irrigation channels, sometimes a mile or more in length. P. R. T. Gurdon who held the Khasi method of manuring to be “much in advance of any system of natural manuring to be seen elsewhere in the Province” described their system of wet rice cultivation as follows :⁸

The soil is made up into a thick paste in the Jaintia Hills by means of the plough and in the Khasi Hills through the agency of the hoe. Drove of cattle also are driven repeatedly over the paddy fields until the mud has acquired the right

consistency. The seed is then sown broadcast in the wet mud. It is not sown first in a seedling bed and then transplanted, as in Assam and Bengal.

Side by side with agriculture, the Khasis are traditionally used also to horticulture and bee-keeping.

Production of grains has always been deficient in the hill region. Hence, the diet had to be supplemented with all kinds of cultivated and wild edible roots and greens as well as by hunting and fishing. Any kind of vegetable oil and refined or semi-refined sweetening material was generally not in use amongst the hill tribes until recent times. Their abhorrence to milk and milk products—except in certain pockets of Tibetan influence in NEFA—persists till this day. However, the breeding of livestock as a source of meat supply and for ritual purposes, has been important in the hills. Pig-rearing and poultry-keeping are common to all tribes. Mithan (*bos frontalis*) as a semi-domestic animal is present in almost all the hills ; but oxen are found only in areas that have close connections with the valley.

The very simplicity of tribal society hindered specialization of economic activities. Nevertheless some tribes—rather some villages within tribes—were indeed specialized in weaving, pottery, basketry and in trading. The technology was, however, much more backward than what prevailed in the valley. For example, the potter’s wheel, four-footed hand-loom, oil-press, sugar-mill and foot-operated rice-pounder (Dhenki) were not known to the hills. Hillmen made little or no use of pack animals. They used to carry everything—even the goods for barter—on their backs. Baskets, slung over the back and suspended by a stout strap across the brow, were used for carrying goods. Only in Bhutan and Western Kameng, the use of yaks and ponies as beasts of burden was as common as the human transportation. Water-mills are used in Western Kameng, as in Bhutan, for the grinding of wheat (wheat was rare elsewhere in the region). Wooden block-presses for printing religious books in their monasteries had been in use since at least the 17th century. But these had no impact on the people of the neighbouring hills and the plains of Assam. The only other tribe using water mills were the Khamtis, who migrated from Upper Burma into Assam in the late 18th century.

Extensive forest and wasteland resources made life easy in the hills in many respects. Timber, bamboo, reeds, thatching grass and canes were free forest products. These were used in the construction of houses or in making tools, weapons, canoes, traps, stamping blocks and pounding poles, snares, mats, baskets, and

⁶ Quote from Ashley Eden’s Report (1864) in *Political Missions to Bhutan*, (Calcutta, 1865), pp. 122-23.

⁷ R. B. Pemberton, *The Report of the Eastern Frontier of British India*, (Calcutta, 1835), p. 220.

⁸ Quotes from P. R. T. Gurdon, *The Khasis*, (London, 1914), pp. 39 and 40, respectively.

The only other hill-tribe who are equally manure-conscious are the Monpas of Western Kameng.

ropes. There was very little use of iron except for making weapons. Nevertheless mining and even the smelting of ores were carried on by some tribes. Greater part of the iron production in Khasi-Jaintia Hills was export-oriented. The export of iron lump, hoes, arrowheads and even ploughshares from pre-British Khasi and Jaintia Hills was estimated at anything between 20,000 and 50,000 maunds annually. Even so, the Khasis did not manufacture or use nails because of a taboo.⁹

The resistance of the tribal society to economic changes need not however be exaggerated. Wasteful methods of cultivation persist for lack of other simple alternatives within the reach of their understanding and economic means. The successful introduction and rapid spread of potato as a new crop in the Khasi-Jaintia Hills during the years 1830-40 and later in other hills may be cited as an example of their capacity to welcome a change. The fact that they had already been cultivating a similar but inferior kind of tuber explains this success. Maize, pineapples and chillies—believed to be a contribution of the New World—were firmly established crops in the hill region, already before the British arrival. Horticulture of the Khasis had attained a high degree of specialization by 1828. In that year, their gardens were credited with supplying “almost the whole of Bengal” with oranges,¹⁰ besides a quantity of *pan* leaves and *tezpat*.

Most of the hill tribes had no historical experience of the state organization, as distinguished from their primitive tribal organizations. The Tibetan administration had penetrated into certain pockets of NEFA in the late medieval period. Amongst others, only the Khasis and the Bodo-Kacharis appear to have moved towards organized statehood, several centuries before the arrival of the British on the scene. The petty Khasi village republics of the Jaintia Hills managed to form a loose merger in the form of a kingdom and extend its authority over some non-tribal areas of the plains. The history of this kingdom of Jaintia—where the ruling family adopted Hinduism—can be traced as far back as the 15th century. It continued its existence till 1835. The Bodo-Kachari tribal state, on the other hand, had as its territory not only the North Cachar Hills, but also portions of Assam plains

—the narrow valleys of the Kopili, the Jamuna and the Dhansiri rivers. It partially retained these tracts to the last despite repeated onslaughts of the neighbouring Tai-Ahom Kingdom (1228-1826) of the Brahmaputra Valley. Many border tribes of NEFA and Nagaland were within the Tai-Ahom sphere of influence, but they maintained their autonomous existence throughout. The heartland of NEFA, however, was a sort of stateless no man's land between Assam and Tibet. Independent tribes therein had trade relations with both.

Even in medieval times, the difficult hill region was not closed to trade. There is evidence of the use of regular caravan routes through Bhutan and NEFA by pilgrims and traders of Tibet and India, from the 13th century onwards or even earlier. Similarly, some trade routes between the Brahmaputra Valley and Yunnan in China passed through the hill region. Because of difficult navigation on the Brahmaputra (to be explained below), the 130-mile land route passing through the Jaintia Hills—from the ancient mart of Sylhet (now in Bangladesh) to Raha in the Assam plains—was also important during the medieval times. Jaintiapur (now in Bangladesh), the foothills capital of the State of Jaintia, served as a great entrepot for barter trade in cotton, iron, wax, ivory, betel leaves and cloth for salt, tobacco, rice and goats from Bengal in early 19th century.¹¹ Hence trading had already become an important economic activity for the Khasis, even in pre-British times.¹² As early as the 18th century cotton of the Garo Hills found its way to Bengal, on a considerable scale, through a chain of foothills markets and fairs. Garo traders used to procure Bengal salt and sold it in the foothills marts of the Brahmaputra Valley.

With the mode of cultivation described above, the hill economy could hardly have supported any sizable population. Even amongst the most advanced tribes, the density of population could not have been presumably more than some 20 or so per square mile. Realistic conjectures can be made on the basis of the earliest available census figures which predate any appreciable demographic impact of the British rule in the region. This is done in Table 1.

⁹ A. J. M. Mills, *Report on the Khasia and Jaintia Hills*, 1853, (Shillong, 1901), p. 4.

W. J. Allen, *Report on the Administration of the Cossyah and Jyntiah Hill Territory*, (Calcutta, 1858).

Gurdon, n. 8, p. 30.

¹⁰ Letter from G. Lamb, dated Dacca the 30 April 1828 in *Foreign Secret Proceedings*, Government of India, 14 November 1828, No. 3.

¹¹ Ibid., Pemberton, n. 7, pp. 75, 214 and 219. Sylhet (Srihatta) is mentioned in a copper-plate as early as the 11th century (Bhatera Grant).

¹² “Wilson's Account of the Burmese War” in Pemberton, n. 7, p. 219. In 1824, the majority of the people in many petty states of the Khasi-Jaintia Hills were found to depend for their livelihood on trading activities.

TABLE 1
Population of the Hill Region : Northeast India

District	1881	1891	Density per sq. mile (1881)
Assam :			
Khasi-Jaintia Hills	167,804	197,904	28
Garro Hills	109,548	121,570	35
North Cachar and Mikir Hills }	24,433 77,765		12 ?
Mizo Hills (Mizoram)	n. a.	43,634	(Less than 11)
Other Areas :			
NEFA	n. a.	n. a.	(Less than 10)
Manipur	221,070*	n. a.	67
Tripura	95,635*	137,442	23
Naga Hills	96,480	97,556	31

Source : Census Reports.

* In Manipur three-fifth of the population lived in the 700 sq. mile central valley ; the actual hill people numbered only 85,288. In Tripura, the hill tribals (50,000 approx.) constituted slightly more than 52 per cent of the population. Majority of the remaining 48 per cent were of migrant origin, and were living on the plains.

In 1881, the density of population per sq. mile in the Khasi-Jaintia Hills and the North Cachar Hills was 28 and 12, respectively. The average density for the entire hill tract, covered by the 1881 census, was 19 per sq. mile. NEFA was brought under census operation, for the first time, in 1961. The density of population there was hardly 10 per sq. mile in that year. Assuming a static density of 10 persons per sq. mile for the medieval times, the hill region of North East India might have supported at the most a population of not more than 0.9 million. The actual population apparently was even less than that.

III

The Economy of the Plains : Three Belts

The Brahmaputra Valley (22,000 sq. miles) is an alluvial plain, about 450 miles in length from east to west and with an average breadth of about 50 miles from north to south. The valley is thus shut in on every side except on the west. However, a number

of narrow passes across the hills have facilitated trade and migration from times immemorial. For example, *Tabaqat-i-Nasiri*—a 13th-century historical work in Persian—was aware of India's trade with Tibet passing through as many as 35 such passes lying between Tibet and Kamarupa.¹³ The 311-mile trade route from Udalguri in Assam plains to Lhasa via Tawang remained important throughout the 19th century.

The valley is criss-crossed with a large number of tributaries of the Brahmaputra. The greater of the northern streams are snow-fed. Those from the south—except the Dihing—depend exclusively on the annual rains for their volume. They shrink—some even dry up—during the winter. These tributaries, therefore, offer navigation facilities only on a limited scale. Many of them—and the upper courses of all of them—are generally not navigable except for dug-out canoes in the dry season. On the other hand, the navigation of the Brahmaputra in the rainy season, though favoured with westerly winds, is extremely hazardous, uncertain and dangerous for any boats, other than canoes. This is because of crashing banks, floating trees and difficult tracking along the jungle-covered banks. This explains the preponderance of dug-out canoes on Assam waters, as noted by several 17th, 18th and early 19th century sources. Canoes are generally capable of carrying one to two hundred maunds of goods or more. An exceptionally large-sized one (*holong*) could carry upto 800 maunds.

A moderate-sized boat used to take, on an average, four to six weeks to go from Dacca to Gauhati. The 450-mile distance between Goalpara and Sadiya—the two ends of the Brahmaputra Valley—could be made, according to Butler (1847), in 34 days by a *budgerow* of Bengal. "At present the ordinary time taken by a country boat of 1,000 maunds' burden from Calcutta to Dibrugarh" wrote Major Vetch in 1853 "is as great as that of a voyage round the Cape to London by a sailing-vessel."¹⁴ These

¹³ H. M. Elliot and J. Dowson, ed., *History of India as told by Its Own Historians*, 8 vols., (London, 1866-7), II, p. 311 ff.

In early 19th century, Pemberton, on his way from Dewangiri to Tasgong in Bhutan, met several parties—about 400 persons in all—leading their asses laden with salt towards Hajo. At Dewangiri, he had found that about 2,000 people from Tibet had assembled for a trading-cum-pilgrimage mission to Hajo. "Pemberton's Report on Bhutan", in *Political Missions to Bhutan*, (Calcutta, 1865) p. 77.

¹⁴ *Calcutta Review*, XXI (July-December 1853), p. 394 ; Capt. John Butler, *Sketch of Assam*, (London, 1847), p. 15 ; J. M'Cosh, *Topography of Assam*, (Calcutta, 1837), 28.

Quote from Vetch to Mills, 22 June 1853 in A. J. M. Mills, *Report on the Province of Assam*, (Calcutta, 1854), Appendix C.

The lofty boats, built with keels and rudders, which plied on the

circumstances should not be lost sight of in estimating the extent of the river-borne trade in medieval Assam. The total length of Assam's navigable rivers, given by *Imperial Gazetteer* (1885) as 3,711 miles for an area of some 24,000 sq. miles, has to be interpreted in the above context.

Chāpari belt

Topographically, the entire valley may be broadly divided length-wise into three belts—each passing through all its six districts. In the middle, lie the sandy, alluvial banks of the Brahmaputra and the shoals and islands therein. This riverine belt known as the *chāpari* area is heavily flooded during the rains. Here, cultivation involves annual slash-and-burn of the grass and reed jungles before the commencement of ploughing. Crops raised on such lands are highly uncertain because of frequent untimely floods. Traditionally, *chāpari* lands used to be put under two major crops, early-maturing rice (*ahu*) and mustard, sometimes with the advantage of double-cropping.

There are, on the Brahmaputra, only a few naturally-protected locations like the townships of Goalpara, Gauhati, Tezpur, Silghat and Biswanath, where there are some scattered hills right on the bank itself. Everywhere else the Brahmaputra flows between soft, sandy banks and overflows the country for several miles during the rains. So, the sandy belt is subject to constant change for a breadth of some six miles or so on either side of the river. At places, in the district of Goalpara, it may extend even upto 20 miles from bank to bank. The nature of its frequently-shifting channel can be gauged from certain recorded observations. Before 1790 the Brahmaputra used to flow down a channel—now unimportant—north of the Majuli island. At that time, the Dihing used to pass through the former's present channel. Comparing a map of 1790 with one of about 1860, Col. Shakespeare further came to the tentative conclusion that the Brahmaputra's course below Gauhati had shifted about 50 miles southwards within this period.¹⁵ It is also probable that the Brahmaputra and the Lohit rivers were, in the remote past, flowing much closer to the Abor and Mishmi Hills than today. The preponderance of *chāpari* lands in the Barpeta sub-division of today appears to corroborate Shakespeare's contention. The *perganah* of

Ganges between Calcutta and Patna suited the Brahmaputra only in the rainy season, and would not suit its rapid and shallow tributaries. Generally, boats on the Brahmaputra used oars, rather than rudders. They had no keels—so necessary for sailing. They descended with the stream and returned by the track-rope.

¹⁵ L. W. Shakespeare, *History of Upper Assam, Upper Burma and North-Eastern Frontier*, (London, 1914), pp. 5-6.

Barpeta is so low that the village sites there were artificially raised "and in the rains the whole country presents the appearance of a vast lake."¹⁶ Presumably the valley was not free from such ravages of the Brahmaputra in medieval times. The spread of civilization in the valley was subject to the constant pressure of these ravages.

It is because of this changeful course of the river that the *chāpari* belt remained long under shifting cultivation. Till the beginning of our century, it was devoid of habitation barring isolated *pām bastis* or temporary settlements of seasonal migrants who used to grow mustard, pulses and *ahu* rice. Presumably, medieval villages and towns were not founded close to the Brahmaputra, except at the few naturally-protected sites, already mentioned above. The early 19th-century administrative reports of British Assam note that for a distance of about 200 miles below Sadiya, there was not a single river-side town or important village on the Brahmaputra.

Rupit belt

Away from the sandy belt, the alluvium is more consolidated and mostly consists of clay. This is the *rupit* belt which stretches on either side of the *chāpari* belt and it includes the most fertile strips of the valley. It is there that the low, flat fields of late-maturing transplanted paddy, interspersed with slightly-elevated permanent village and garden sites as well as occasional mounds are concentrated. (The word *rupit* actually means transplanted paddy.) The rainy season floods all these rice fields to the depth of a few inches every year. Besides abundant direct rainfall (75 to 100 inches), every year they receive the spill-over of the Brahmaputra and its tributaries. However, the former's fertilizing influence should not be exaggerated. What is deposited is mostly sand, while the rich silt is carried off to the plains of Bangladesh. It is not so with the tributaries which are often tapped for gravitational irrigation. The whole rice plain turns into a luxuriant greenery that begins to dry up after September, and the ground is already hard by late December.

It was in the *rupit* belt that the plough-using people had, in all probability, their earliest permanent settlements. These low-lying flat lands were thickly-forested under natural conditions. But the settlers with an abundant supply of iron implements and iron-tipped heavy ploughs, could uproot the tree-jungles. However, the clayey soil and a rainfall of 75 to 150 inches combined to foster thick unmixed forests of *sal*, *nahar*, *holong* and other

¹⁶ E. T. Dalton in *Journal of Asiatic Society of Bengal*, XX (1851), pp. 455-6.

gregarious trees in many pockets so that the task must have been difficult even for them. Many such tracts in Goalpara, Lakhimpur and Cachar were obviously by passed. People with inferior implements preferred as their habitat either the *chāpari* belt (e.g., the Miri tribe who began to come down to the plains in the 13th-15th centuries) or the submontane belt (as in the case of the Bodo-Kachari tribes). In both cases, the scrubby and bushy grass jungles in those belts suited their 'slash and burn' farming methods.

Submontane belt (Dooārs and Tarai)

The submontane belt skirts around the heart of the valley, all along the foothills. This belt of undulating, and at places slightly elevated, plains is under scrubby forests and high-grass savannahs. In most places, the belt receives a heavy annual rainfall of some 80 to 120 inches. The only exceptions to this are the contiguous, narrow valleys of the Kopili, the Jamuna and the Dhansiri. In these parts, the rainfall approximates 45 to 60 inches. Numerous hill streams with their shallow and shifting channels make artificial irrigation an easy proposition. Bodo-Kachari tribes made use of this opportunity in the past, as they still do today.

Weeding is as much difficult in the submontane belt as on *chāpari* lands. Weeds grow so fast and require so much efforts for their suppression that it is more economic to burn and plant fresh virgin plots than continued cultivation of the same old plots. Thus, here too a system of shifting cultivation, with or without plough, prevailed till recently. Undulating or sloping plains allow easy running-off of water. So, the cultivation of wet rice here is somewhat limited, and the dry crops tend to predominate. Dry lands, however, can be levelled and turned into wet rice lands.

It is this belt and adjacent low hills which, for centuries, remained the habitat of the migratory Bodo-Kachari and allied people of the Tibeto-Burman linguistic group. Their methods of shifting hoe-cultivation were preserved as late as the 19th century, as we know from Buchanan-Hamilton (1809-14), Fisher (1833), Hodgson (1847) and Dalton (1872).¹⁷ However, in

¹⁷ B. H. Hodgson, *Essay the first on the Kocch, Bodo and Dhimal Tribes*, (Calcutta, 1847), pp. 47, 154-6 and 180.

E. T. Dalton, *Descriptive Ethnology of Bengal*, (Calcutta, 1872, reprint 1960), p. 81.

Fisher to Robertson on Dharampur, dated Cachar 12 March 1833, *Foreign Political Proceedings*, 6 June 1833, No. 107 (National Archives).

Francis Hamilton, *An Account of Assam, 1807-14*, (S. K. Bhuyan, ed., Gauhati, 1940), p. 73.

Kamrup and Darrang, as a result of closer contacts with the settled population, they had adopted both plough cultivation and wet *salī* paddy quite early. But even there they had little attachment to their villages as they lacked in orchard cultivation. Jenkins (1851) praised them as efficient cultivators, but at the same time, noted their unsettled habits.¹⁸ It is not possible to say when exactly the transition to plough cultivation took place amongst them. There is an oblique reference, in an old Assamese chronicle, to the damming of a hill-stream by a cattle-owning Bodo-Kachari tribe of the 13th century.¹⁹ This might suggest of artificial irrigation as early as that date, but does not positively confirm plough cultivation as such. Domestic cattle were probably used only as a source of meat and not for drawing ploughs. An analogous example may be given from recent times. The Meches, a Bodo-Kachari tribe of Jalpaiguri district bordering Assam, "go in for artificial irrigation in a surprising manner, and I have noticed their water channels more than a mile long" wrote Col. Money, the Deputy Commissioner in 1875. But at the same time he pointed out:

... the Meches find the proximity of permanent cultivation not to be congenial to their own habits. ... I have of late observed that Meches are using ploughs much more freely than they used to do, and also that in many places they employ Rajbansis to plough for them.²⁰

In 1875, then, the Meches were going through a process of learning the use of ploughs from their more advanced neighbours, the Rajbansis. This happened despite their being experts in artificial irrigation.

People of the *rupit* belt had also interests in the two other belts of apparently waste lands, lying within their reach. They collected all sorts of materials for the making of their houses, boats, implements, mats and baskets, from these tracts. At selected spots on these tracts—often several miles away from their settled villages—peasants would erect their temporary clusters of huts, known as *pām bastis*, to carry on shifting cultivation of

¹⁸ *Bengal Revenue Consultations*, 31 December 1851, No. 44, Jenkins to Board of Revenue, 12 November 1851.

¹⁹ "Banhgariia Burha Gohainar Buranji" in *Deodhai Assam Buranji*, (S. K. Bhuyan, ed., Gauhati, 1962), p. 100.

A. Guha, "Ahom migration: its impact on rice economy of medieval Assam", *Artha Vijnana*, IX, 2 (June 1967), pp. 144-5.

²⁰ Quoted by D. H. E. Sunder's Settlement Report of 1895 in Appendix IV, *Census 1951 West Bengal District Handbooks-Jalpaiguri*, (Calcutta), p. cl XVI.

mustard, pulses and *ahu* rice. This type of cultivation was more prevalent in the district of Kamrup than elsewhere. The pressure of population on the *rupit* belt of North Kamrup led peasants of all categories to resort to this practice, irrespective of their tribe and caste. Butler has described how this form of agriculture as practised in Barpeta Sub-division of Kamrup in 1847, differed very little from what is known as *jhuming*, except for the use of plough.²¹ During the early years of British administration, individual holdings for shifting cultivation on the common waste lands could not be settled otherwise than on annual leases, despite the authorities' bias for permanent or periodic rights in soil. Today one misses the scene of firing grass jungles as described by Butler, because the settled areas in the *chāpari* belt of Barpeta Sub-division underwent a 700 per cent increase during the years 1911-30, as a result of large-scale immigration from East Bengal.²²

Side by side, there also existed intensive cultivation of wet paddy and manured garden crops in Lower Assam even prior to the 13th century. The mass of agricultural knowledge codified into the "Sayings of Dāka", is a common oral tradition, shared between Lower Assam and Bengal and certainly pre-dates the Tai-Ahoms.²³

In the diet of the valley people, rice played a more important role than in the hills. Wheat was rare. A wide variety of edible greens, milk and fish and meat when available, supplemented the rice diet. Apart from expensive rock-salt and Bengal salt, an alkali substitute was also universally prepared from the ash of burnt water-herbs and barks of plaintain trees. Vegetable oil of any kind, hardly used by the hill tribals, was used in scant quantities in the plains. Bullock-drawn oil-presses and oilmen's castes were rare. Oil from mustard seeds used to be extracted in every house with the help of a short stone-loaded beam. Cultivation of sugarcane and manufacture of *gur*, though widespread, was more concentrated in the districts of Kamrup, Sibsagar and Lakhimpur. At the beginning of this century the districts of Sibsagar and Lakhimpur, between them, were growing 62 per cent of the total sugarcane production of the Brahmaputra valley.²⁴

²¹ Butler, n. 14, pp. 21-3; Guha, n. 19, p. 138.

²² *Report of the Assam Banking Enquiry Committee*, 1929-30, I (Shillong, 1930), p. 23.

²³ According to Dāka, the larger the number of dykes or ridges thrown across the field, the better will be the *Sālī* crop.

²⁴ *An Account of the Province of Assam and its Administration*, 1901-2 (Shillong, 1903), Table on p. 23.

IV

The Economy of the Plains: Another Look

The Brahmaputra valley, from another angle, may be divided into two sub-regions—Upper Assam and Lower Assam.²⁵ Historically, these two sub-regions had undergone dissimilar conditions. Western part of Lower Assam was never under the political control of the Tai-Ahoms. It constituted a part of the Mughal territory since the 17th century; and after 1765, of British India. The remaining parts of Lower Assam, i.e., Kamrup and Mangaldai, were under direct or indirect rule of the Mughals, for several decades in the 17th century. It was in low Assam and North Bengal that the Koch (Rajbansi) tribe—most probably of Bodo-Kachari origin—established their rule at the start of the 16th century. The Koch power was at its height, when in 1562 the Tai-Ahom capital at Garhgaon was sacked by its army. Thereafter it was gradually encroached upon from the west by the Mughals and from the east by the Tai-Ahoms. As common heirs to the ancient Kamarupa, North Bengal and Lower Assam shared not only a common history, but also a common spoken language through the medieval times.

Lower Assam merges into the flora of the Upper Gangetic plains, while Upper Assam is dominated by South-East Asian flora. The differences in the natural vegetation as well as in the ethnic composition of these two sub-regions have become somewhat blurred through centuries of intermingling. They were presumably more pronounced in the past than in the present day. Households in Upper Assam chiefly produce *sali* rice, but also such crops as sugarcane, pulse, oilseeds and dry (*ahu*) rice. Tea jungles used to grow there in wild state before 1840. Pre-monsoon rainfall of 10 to 15 inches and monsoon rainfall of 50 to 70 inches are ideal for rice; hence it is abundantly grown all over Assam, as in Tripura and Manipur. In Lower Assam, both wet and dry rice, mustard, sugarcane and pulses grow. Potato and tea were introduced during the early British period. Jute, which is now important as a commercial crop, was—like indigenous *rhea* (*Urtica nivea* Linn.)—a marginal garden produce in pre-British days. Poppy cultivation, unknown earlier, attained its ruinous importance only during the years 1770-1860. Its cultivation was prohibited thereafter. The early arrival of tobacco in Assam—the Portuguese brought it to India in 1508—is to be noted. A

²⁵ The districts of Goalpara and Kamrup together with the sub-division of Mangaldai constitute what is called Lower Assam. The rest of the valley is known as Upper Assam.

local chronicle of the 17th century mentions the purchase of tobacco leaves (*dhuāpāt*) near Singri in Central Assam by a Bengal merchant in violation of the ban on the entry of foreign traders into the Tai-Ahom territory. His boats were confiscated and the tobacco leaves—but not the mustard seeds and pulses purchased—were forwarded to the capital for royal perusal. This decision to send only the tobacco leaves to the exclusion of the other confiscated goods, suggests its being a curio in Upper Assam in early 17th century.²⁶ Both Welsh (1794) and Robinson (1841) later mentioned the existence of tobacco cultivation all over Assam.²⁷ Throughout the medieval times, areca nuts, pepper and cotton were important items of cultivation. Cultivation of indigo on a limited scale is traceable from the 18th century. Fishing communities cultivated *rhea* (*Kānkhurā*) as source of fibre for making their fishing nets and ropes.

Cachar Plains

The Cachar plains with approximately 2,680 sq. miles in area are alluvial level stretches except where broken up by isolated hillocks and low ranges of hills which project from the surrounding mountains. The chief river is the Barak which is from 100 to 200 yards in width and in places over 70 feet deep. It is liable to overflow its banks during the monsoons, but does not shift its course. Consequently, there are no *chāpari* lands in Cachar plains. The annual rainfall averages to 130 inches or so, with liability to floods from June to October. Despite some differences in land formation and climate, the Cachar plains closely follow the broad pattern of the Upper Brahmaputra valley. Cachar remained thickly-forested until it attracted considerable migration from Assam and Sylhet plains during the 18th century. Ivory, wax, cane, bamboo and timber were the exports from Cachar to Bengal.²⁸

In fact vast tracts of land must have remained waste in the

²⁶ George Watt, *The Commercial Products of India*, (London, 1908), p. 796 and

"Bānhgariia Burhā Gohāinar Buranji", n. 19, p. 110.

²⁷ Report by Welsh dated 24 February 1974, *Foreign Political Proceedings*, No. 13 A (National Archives).

William Robinson, *A Descriptive Account of Assam*, (Calcutta/London, 1841), pp. 65-84.

A. Guha, "Colonisation of Assam: years of transitional crisis (1825-40)", *The Indian Economic and Social History Review*, V, 2 (June 1968), pp. 125-6.

²⁸ Letter from Raja of Cachar received at Calcutta on 29th July 1797, S. N. Sen, ed., *Prāchin Bāngalā Patra Sankalan* (Calcutta University, 1942), p. 75.

Brahmaputra valley throughout the medieval times. The 13th century Tai-Ahom conqueror is reported to have noted that "the country around Dihing was uncultivated and wild."²⁹ Shihabuddin Talish, the author of *Fathiyya-i-ibriyya*, (1662), also observed that there was a greater tract of uncultivated lands in the south of the Brahmaputra than in its north.³⁰ Obviously, by north he meant North Kamrup and adjoining areas through which the Mughal army had passed. In fact, the trans-Dihing forests continued in existence down to the early years of British rule. But, at that time, Assam's population was at its lowest level (less than a million), and forests and wastelands in every district outstripped cultivation. Some relevant available data consisting of an estimated percentage of the total area under cultivation in 1874-75, density of population per square mile in 1872 and estimated number of persons maintained per square mile of cultivation, as of 1853, for each district, are given vide Table 2.

TABLE 2

District	% of area under cultivation (1874-5)	Density per sq. mile of total area (1872)	No. of persons per sq. mile of cultivated area (1853)
Goalpara	50	98	209
Cachar	20	99	?
Kamrup	19.9	146	690
Sibsagar	17.5	102	623
Nowgong	10.3	79	874
Darrang	9.5	69	535
Lakhimpur	4.2	29	637

Sources : 1. *Administrative Report, Assam, 1874-75*. 2. *Census of India, Assam Report, 1901*, p. 10. 3. "Statistics of Assam—July 1853" in Capt. John Butler, *Travels and Adventures in the Province of Assam*, (London, 1854), p. 268.

Note : The data related to cultivation are not above doubts.

However, in the mid-17th century, the agriculture of Assam appeared to be in far more flourishing conditions, with a considerably lesser area being occupied by forests and wastelands.

²⁹ Quote from J. P. Wade, comp., *An Account of Assam*, (compiled 1794-1800; Benudhar Sharma, ed., North Lakhimpur, 1927), p. 17.

³⁰ Jadunath Sarkar, trans. extract from *Fathiyya-i-ibriyya* in *Journal of the Bihar and Orissa Research Society*, I, pp. 179-94.

Nevertheless, large-scale fluctuations from time to time in cultivated area within each district must have been a general feature also in the past, because of frequent ravages of rivers, warfare and consequent population movements.

What could be the population of Assam plains at the height of its prosperity during the first half of the 18th century? One can only conjecture. Gunabhiram Barua's estimate of 2.4 million around 1750 appears to be probable.³¹ The population came down to less than one million by 1830, because of the civil wars (1770-1810) and the Burmese invasion (1819-25), and also because of the ruinous effects of opium on the people. It was restored to its former size only by the 1870s, partly through natural growth and partly through immigration.

V

The Composition of Population : Brahmaputra Valley

The traditional pattern of population distribution was considerably affected by large-scale immigration since 1901. On the other hand, the first census of 1872 was imperfect and incomplete in many respects. Hence, an attempt will be made to comprehend the ethnic and caste composition of the medieval population, on the basis of the census data of 1881.

The Brahmaputra valley had a population of 2,249,185 persons in 1881. Of this, an estimated 3 lakhs were of recent immigrant origin or immigrants themselves. The rest were indigenous of Assam. Muslims (208,431) constituted 9.3 per cent of the whole valley population, but a quarter of the population of Goalpara district. The population strength of important plains tribes and Hindu castes are given in Table 3. A scrutiny of the table suggests that almost one-half of the indigenous valley population was comprised of non-Hindu and such tribes as had been converted into Hindus within the preceding two centuries or so.

The Kalitas, more than half of whom were concentrated in Kamrup, numbered 241,589 in 1881. They are regarded as a high caste and ranked next to the Brahmins (68,784), Daivagnas (17,390) and Kayasthas. They are an agricultural community who are generally believed to have entered into Assam from the west. According to Dalton, they were the remnant of the earliest Aryan colonists of Assam. Whatever be their racial

TABLE 3
Population of Major Castes and Tribes : Brahmaputra Valley (1881)

(Total Population of the Valley = 2,249,185 persons)

I Bodo-Kachari Tribes uninfluenced by Hinduism		
Kachari		265,418
Mech		57,885
Lalung		46,077
Hajong		3,689
Garó (plains)		23,373
II Bodo-Kachari Tribes in the process of conversion		
Rabha		56,285
Modhahi		13,149
Mahalia		6,198
Sarania		4,718
Totila		2,539
III Castes formed of converted Bodo-Kacharis and allied tribes		
Borahi	(extinct)	
Moran	(not reported ; almost extinct)	
Chutiya		59,163
Koch or Rajbangshi	}	336,739
Total Bodo-Kachari Elements		875,233
IV Miri Tribe		25,636
V Hindu Castes		
Kalita		241,589
Ahom (Tai-Ahom)		179,283
Kaivarta		105,317
Dom (Nadial)		96,779
Katani and Jugi		81,931
Brahmin		68,784
Ganak (Daivagna)		17,390
		791,073
VI Muslim		208,431

Source : *Assam Census Report*, 1881, pp. 22-34 and pp. 63-102.

origin, they appear to have always been associated with plough cultivation, so far as knowledge goes. The Kalita caste has some functional sub-divisions within itself. In Kamrup, these functional sub-divisions—Māli (gardener), Kamār (blacksmith), Tānti (weaver), Sonāri (goldsmith), Kumār (potter), Nāpit (barber) and Nat (dancer-acrobat), etc., together grouped as Sarukalita, are said to be debarred from the privilege of close intercourse with the Barkalitas (high Kalitas). In Sibsagar, a

³¹ S. K. Bhuyan, *Anglo-Assamese Relations, 1771-1826*, (Gauhati, 1949), p. 1.

section of the Kalitas are functionally Naotalia (boat-makers).³² In practice, the functional sub-divisions had never been very rigid. Here, incidentally, it may be noted that the Kalita-Kumars have been associated with the use of the potter's wheel, while the potters of the Hira caste did not know the use of it at any time. The Hiras do not use any furnace, but burn their pots on the open surface. Hira women fashion the pots, while their menfolk bring the clay and sell the products.

The Koches or Rajbangsis (336,739) were originally a tribe of North Bengal and the district of Goalpara. They were given a Hindu caste status by the 16th century. Later, in adjoining Assam Proper, this caste status was thrown open to all new converts to Hinduism from various tribes. To become a Koch meant much more than mere religious conversion. It meant the adoption of plough in place of the hoe, of mud-plinth dwelling in place of pile-house dwelling and of cremation of the dead instead of burial. It also meant the gradual abandonment of pig-rearing, abstinence from liquor and the adoption of a Sanskrit-based neighbouring language in preference to their own tribal tongue. The conversion had some indirect economic impact as well. Absence of pigs around one's homestead proved beneficial for garden-culture, which again encouraged settled habits. But the growing prejudice against rice-beer was perhaps one of the indirect contributory causes of the Assamese lust for opium in a later period. A tribal could progressively realise the caste status of a Koch through stages. "We do know for certain," wrote E. P. Stack "that a process of this kind goes on among the converted Bodo, who first become Sarania, Madhahi or Totila, and then develop into Koch."³³ It has been noted that in North Bengal and the adjoining Goalpara district of Assam, an entire tribe was transformed into the new Hindu caste of Koch. Now, as this status was thrown open to all neo-converts, the former preferred to be called *Rajbangsis*, instead of Koch.

Of the Koch who retain their proper names, three divisions are recognised in Goalpara, Kamrup and Eastern Darrang. These are :

1. *Kamtali* who abstain both from liquor and pork ;
2. *Haramia* who abstain from liquor only ;
3. *Modhahi* who are Hindus but take liquor.

³² *Assam Census Report*, 1901, p. 133.

The attempted distinction between Barkalita and Sarukalita has never been observed strictly. Today, in any case, all the Kalitas together constitute an endogamous group ; most probably, it was so also in earlier times, the tendency of fission being a passing phase.

³³ Quote from *Assam Census Report*, 1881, Chap. VI, p. 66.

The process of the promotion of Bodo-Kachari, Lalung, Mikir and other plains tribals up the ladder of Sanskritisation has been continuously going on. Yet the small 12 per cent rate of increase in the population of the Koch caste between 1872 and 1881 is somewhat misleading. It may be safely assumed that a number of Koch, specially in the eastern districts, did return themselves as belonging to some higher caste, such as Kalita or Keot.³⁴

The Keot or Kaivarta (105,317) is another agricultural caste, as distinguished from Jaloa Keot (pani-Kaivarta) which is a fishing caste. Another fishermen's caste is designated generally as Nadial (or Dom) (96,779). The Hāri (Brittial) caste was assigned the sweeper's duties by the Tai-Ahom rulers. Later, they converted themselves into goldsmiths. It is the Nadial, Hari, Hira, and few other untouchable castes who were put at the lowest end of the social scale. Yet another important caste is that of the Nath-panthi Jugi or Katani community (81,931). Although weaving and spinning were universal with medieval Assamese households, the spinning of the *Pat* (mulberry) variety of silk-yarn was an exclusive function of this caste. Hindus though they were, the custom of burying the dead in preference to cremation survived amongst them.

The Chutiyas (59,173) are another tribe converted gradually into Hinduism. Originally a hill tribe, they had settled down in Lakhimpur, already by the 13th century and had established a local kingdom. They were conquered and later absorbed, to a considerable extent, by the Tai-Ahoms. Despite this, they have survived as a separate Hindu caste. In 1911, 65 per cent of the Chutiyas were enumerated in Sibsagar and 22 per cent in Lakhimpur district. Their original language, now almost dead, is believed to have been close to the Bodo-Kachari language. But this remains yet to be established.

The Tai-Ahoms (179,283) settled down in Upper Assam as migrants from Upper Burma in the 13th century. They belong to the Tai or Shan race which extends in scattered pockets from Assam to Tongking and southwards to Bangkok and Cambodia. They had their own written language which, although dead by now, is still cultivated by a handful of their erstwhile priests. The original Tai-Ahom settlers liberally absorbed Chutiya, Moran and Borahi tribes into their fold, and after some three hundred years of separate identity adopted Hinduism and Assamese language by the 17th century. They also adopted mud-plinth dwelling and the practice of cremation. Since then they have been recognized as a Hindu caste in Assam. Although dominant

³⁴ *Ibid.*, p. 75.

politically, they were not regarded as a high caste. During the 19th century, their number was enumerated as follows :

1872	1881	1891
128,980	179,314	153,211

More than 94 per cent of the Tai-Ahoms are found in Upper Assam. Although they ruled over Assam for more than 600 years, they constituted hardly 10 per cent of the total population in their dominion, at any time. Later migrants of Tai race — Khamtis and Shans — were Buddhist by faith and numbered 3,158 in 1881. The Chutiya, Moran and Thengal-Kachari communities came so much under Tai-Ahom influence, that many of them described themselves as Ahoms, before the Census enumerators.

From Table 3, it appears that more than one-third of the population of the Brahmaputra valley are ethnically of Bodo-Kachari origin. If we keep in view the process of conversion completed in the remote past and also the fact that some of the Muslims must have been converts from the Bodo-Kachari stock, we cannot but conclude that the Bodo-Kachari element in medieval Assamese society was much more prominent than what the census of 1881 suggests. By the term 'Bodo-Kachari' is meant all such allied tribes as Boro, Kachari, Mech, Rabha, Dimasa, Hojai, Hajong, Lalung, Tiprah and Garo, scattered over different parts of northeast India. It is likely that the Chutiyas and Morans are also of Bodo-Kachari origin. The Bodo-Kacharis and other tribes of Tibeto-Burman group, the Miris and the Mikirs of the plains, were learning the use of plough from settled populations in course of centuries. The process is not yet complete.

Before we close this account we may refer the reader to the Appendix at the end which gives a detailed caste classification of households, in Nowgong district for 1850-51. This is one of the oldest available analysis of the early British period.

The indigenous caste-structure of Assam does not reflect the existence of any trading caste of significance. Such caste is conspicuously absent in Upper Assam. But in Lower Assam there is a small trading community, called nowadays Vaishya-Saud (Sunri), a counterpart of the Saha caste of Bengal. They have been carrying on trade from the remote past. Chand Sadagar of medieval folklore belonged to this caste. Besides, the Kalita craftsmen of Kamrup — silk-weavers and bell-metal artisans — used to sell their specialised products as itinerant traders all over Assam. People of Barpeta were described as vigorous traders by the early 19th-century British administrators.

Their boats, laden with surplus mustard-seeds of Assam, used to ply even on Bengal rivers. Folk literature of the 16th century, referring to the trading activities of boat-owning *sauds*, is as much a living tradition with Lower Assam as with Bengal. This suggests the existence of river-borne trade between Lower Assam and other areas during medieval times. Merchandise carried by outgoing boats, according to literary sources, comprised black pepper, long pepper, ginger, cumin seeds, mustard seeds, coriander seeds, incense etc.³⁵ Muslim merchants in the Mughal period were very much interested in the aloes wood (*āgar*) of Assam.

About trade in the Ahom period, Shihabuddin Talish (1662) writes :³⁶

Formerly once a year, by order of the Raja, a party used to go for trade to their frontier near Gauhati ; they gave gold, musk, aloe wood, pepper, spikenard and silk-cloth in exchange of salt, salt-petre, sulphur and certain other products.

Assamese traders (*mudoi*) went as far as Dacca and other places with their boats. Trading activities were not the monopoly of any particular caste. Some Assamese merchants of the 18th century — such as Sibram Sarma Vairagi — were Brahmin or Ganak by caste. The Bengal merchants also came with their *petola* boats to Lower Assam, and even as far as Central Assam.³⁷ During the short-lived Mughal occupation of Lower and Central Assam in the 17th century, there was a Mughal outpost in the village Gorakuchi near Singri which was interested in facilitating trade with Western Kameng and Bhutan. But, war with the Mughals forced the Tai-Ahom rulers to put an embargo on entry of foreign boats into Assam.

River-borne trade of Assam, however, could never be as important as that along the Ganges, because of difficult navigation on the Brahmaputra, as noted above. Heavy rains and soft soils did not permit the use of wheeled carts for carriage, until the introduction of metalled roads in the British period. Trade was further limited by the carrying capacity of canoes on rivers and of pack-animals (limitedly used) and human carriers on land. Assam's balance of trade seems to have been distinctly unfavourable with the rest of India. We get a fair idea of the

³⁵ B. K. Barua, *Studies in Early Assamese Literature*, (Nowgong, 1953), p. 97.

³⁶ See n. 30.

³⁷ S. K. Bhuyan, ed., *Kamrupar Buranji*, (2nd Ed., Gauhati, 1958), p. 44.

traditional river-borne exports and imports of medieval Assam, from the figures recorded for 1808-9. The exports to Bengal included, in a descending order of importance, raw cotton, lac, mustard seeds, *mooga* silk cloth, *mooga* silk thread, elephant tusks, slaves, bell-metal utensils, iron hoes, pepper and miscellaneous forest products—together valuing Sicca Rs. 130,900 only. Imports from Bengal, valued Sicca Rs. 228,300, were mainly salt (84 per cent) and muslin (5 per cent); the rest were various luxury items. In that year, trade was, however, at a very low level, because of a prolonged civil war preceding the date. Nevertheless, the list fairly indicates the composition of Assam's trade with rest of India in late medieval times. In any case, it was, by and large, limited by the extent of local demand for salt.

VI

Main Socio-Economic Features of Assam's Medieval Society

Above is an attempt to weave together significant geographical and historical phenomena and arrive at a general framework of the socio-economic history of medieval Assam. The main conclusions that emerge from this paper are as follows :

Medieval Assam, being relatively isolated from the rest of India, had a peculiar socio-economic pattern of its own. The economy of its plains was very much integrated with that of the hills. Raw cotton, forest products, oranges, rock-salt and iron of the hills were bartered for rice, dried fish, silk and cotton cloth of the plains. This symbiotic relationship was maintained through a chain of foot-hills marts and fairs where both sides met. This trade between plains and hills appears to have been no less important than what passed on between Assam plains and the rest of India, because of the limited scope of navigation on the Brahmaputra. This conclusion is drawn despite the fact that manual transport across the hills had greater limitations which however were overcome by mass participation of the tribes in the transportation of the goods bartered. The total volume of trade—internal and external—was small, but so was the population as well as the total domestic produce of the region. What is to be noted is that the region's economy was far from what could be called self-sufficient.

Assam could not offer enough goods to match the value of her demand for salt imports from Bengal. Hence there was an outflow of gold (collected from river-sand) and also of slaves. The poorer sections of the population—and also the better-off to a

considerable extent—used a preparation of the ash of burnt water-weeds or barks of plantain trees as a substitute for salt. This consumption habit survived till our days. Similarly, the low consumption of vegetable oils freed a considerable quantity of mustard seeds for export to Bengal. This contrasts with the present shortage of mustard-seeds in the state because of the change in the population composition and the consumption-pattern.

Technologically, Assam plains remained far behind the rest of India. Population-scarcity, land-abundance, and continuous migration from hills to plains—all these factors combined together to slow down the transition from shifting hoe-cultivation to permanent plough-cultivation, not only in the hills, but also in the plains. Even the plough cultivation was of shifting nature over large areas of the submontane and riverine belts of the plains. Neither heavy ploughs drawn by several bullocks nor seed-drills were ever in use in this part of India. Rather, plough-shares made out of roots of areca-nut trees or of bamboo often replaced the iron share in the local ploughs. Use of iron, bricks and wheeled carts was extremely limited, although they were known from ancient times. Even the potter's wheel was not universally used by the potters. Neither the construction of residential houses nor of boats made any mentionable use of iron. Only dug-out canoes with no sails were generally made and used in the Brahmaputra valley. With some five men on each boat, they could be pushed along with bamboo poles at the rate of 8 to 10 miles a day when other boats made little progress during the rains. The use of water-mills for milling or grinding grains in some pockets of NEFA has never been imitated elsewhere in the region.

Specialisation on caste lines did not go far in medieval Assamese society. Weaving and spinning were universal with all Assamese women, irrespective of caste and status, thus limiting the scope of professional weavers. Extraction of mustard oil and *gur* was carried on in individual households. However, there was specialisation in the making of bell-metal and brass utensils, earthenwares, ornaments and a few other articles. In these crafts, a certain degree of perfection was reached. Since the 16th century, the manufacture of newly-introduced guns and gun-powder was organized by the state on a high level of skill, which contrasted with the backward technology in general.

Until the 13th century, Upper Assam appears to have been thinly-populated, because of poorer cultivation of the soil. Wet rice cultivation increased rapidly in this region under the Tai-Ahoms. A better supply of food led to a rapid increase of

population and further extension of settled cultivation. This together with their superiority in weapons enabled the Tai-Ahoms to carry on their expansionist wars against the Chutiyas and the Kacharis and to build up a strong State. Hundreds of miles of embankment-cum-roads were built up by them, primarily in the interest of extending wet rice cultivation.

The rice-economy of the Brahmaputra valley was capable of producing considerable surplus. But as difficulties of export came in its way, production was limited by the extent of the local market. This curb on the potentialities forced the Assamese peasants to find an alternative use of their land and labour in the cultivation of poppy, a new crop, during 1770-1860, for local consumption. This totally ruined the people and stagnated the economy for many years to come.

The process of Sanskritisation, going on slowly for centuries, gathered momentum during the period of the liberal Vaishnava movement under the guidance of Sankaradeva (1449-1568), Gopaladeva (1541-1611), Aniruddhadeva (1553-1624) and others. The mass conversion of the Bodo-Kachari tribes and Tai-Ahoms into Hinduism from the 16th century onwards coincided with this movement. This movement led to a politico-religious upheaval amongst the people of Moran tribe and amongst the socially lower castes who allied with the former all over the valley. United under the banner of a particular sect of Vaishnavism, following the school of Aniruddhadeva, they fought against the Tai-Ahom ruling dynasty. A series of devastating civil wars (1770-1810) remained undecided and brought in its wake depopulation, disorder and all-round decadence. This turned Assam into a labour-short economy.

Medieval Assam was essentially a barter economy. Local coinage on a limited scale, however, started from the 16th century. Land revenue was paid in labour, as a general rule, and in produce or money, in special cases. Officials received a portion of the contributed labour in lieu of salaries. This state system³⁸ could be worked smoothly for some five centuries or so because of the essentially tribal basis of the society itself, but from mid-18th century it was facing a crisis.

The most important towns had no more than a few thousand inhabitants during the medieval times; and agricultural and waste lands, on all sides, encroached upon them. In no period did Assam have any large nucleated villages. It had mostly a

hamlet type of human settlement scattered over the agricultural fields, in an elongated, linear fashion along banks of tributaries of the Brahmaputra. The absence of great urban centres thus distinguishes the economic history of medieval Assam from that of contemporary Northern India.

If we keep in mind the geographic environment and the ethnic composition of the people and try to read history backwards from the known recent past to the unknown, as Marc Bloch has done in his *French Rural History* or D. D. Kosambi has done in his life-long research, many gaps in our knowledge of the region's economic past may be profitably filled up, despite the paucity of factual data capable of definitive interpretation.

³⁸ For an account of the system refer to my article, "Land rights and social classes in medieval Assam", *The Indian Economic and Social History Review*, III, 3, (September 1966), pp. 217-39.

APPENDIX

Distribution of Households by Caste in Nowgong District,*
1850-51

(Total No. of Households = 43,795)

Caste—Group	No. of Households	As % of total Households
Koch	8,532	19.5
Plains tribals (mainly Bodo-Kachari)	7,877	17.9
Chutiya	1,458	3.6
Ahom and Shah (Tai-Ahom)	1,877	4.3
Kalita	5,458	12.5
Keot	3,735	8.5
Brahmin	1,475	3.4
Ganak (Daibagna)	126	0.3
Boria	1,751	4.0
Jugi	2,317	5.3
Dom (Nadial)	3,381	7.7
Chandal	1,133	2.6
Hari	194	0.4
Nat	209	0.5
Muslim	2,016	4.6
Moria (Muslim brass utensil makers)	313	0.7
Kamar	125	1.2
Kansari	31	
Koomar	384	
Patia (Mat-makers)	360	0.8
Lonaree (Salt-makers)	111	0.3
Miscellaneous	—	1.9

* The analysis here covers only nine mahals of the district—Nowgong, Koliabar, Mikirpur, Chaporee, Raha, Jamunamukh, Morung, Lakhiraj and Dantipur.

Source : John Butler, *Travels and Adventures in the Province of Assam*, (London, 1854), Appendix H, pp. 266-7. We have presented the data in an abridged form.

7 A Note on the Corvée System (Vethbegār) in the Eighteenth Century Maratha Kingdom*

H. Fukazawa

I

Introduction

Since the late Professor D. D. Kosambi introduced a concept of feudalism in the study of Indian history,¹ several Indian historians have started serious works in terms of the 'feudal' structure of Indian society and state, roughly from the 6th century onward, and many aspects of the structure seem to have been clarified for the period up to the Muslim conquest. R. S. Sharma, for instance, has pointed several characteristics consisting of feudalism in Indian history, such as the grant of lands to Brahmans and later to princes and bureaucrats, sub-infeudation of lands, existence of peasants as semi-serfs, excessive burden of taxation and imposition of forced labour upon them and so on.²

Other historians of India who have likewise stressed a certain feudalism in Indian polity during early medieval period usually point out the existence of forced labour as one of the important aspects of the feudalism.³ Indeed writers on Indian polity before the Muslim conquest almost always refer to a system of forced

* This is a modified English version of my essay in Japanese on the same topic that appeared in *The Hitotsubashi Review*, September, 1962, Vol. 48, No. 3.

¹ D. D. Kosambi : *An Introduction to the Study of Indian History*, Bombay, 1956, Chaps. 9 & 10.

² R. S. Sharma : *Indian Feudalism : c. 300-1200*, Calcutta, 1965, pp. 263-67. See also R. Coulborn : "Feudalism, Brahminism, and the Intrusion of Islam upon Indian History," *Comparative Studies in Society and History*, Vol. X, No. 3, April, 1968, Mouton Publishers, pp. 356-74.

³ E.g. L. Gopal : *The Economic Life of Northern India*, Varanasi, 1965, pp. 26-28. S. A. Q. Husaini : *The Economic History of India*, Calcutta, 1962, Vol. I, pp. 167-68. B. P. Mazumdar : *Socio-Economic History of Northern India (A.D. 1030-1194)*, Calcutta, 1960, pp. 188-90.

labour called *viṣṭi* prevalent there.⁴

On the other hand those scholars who have tried to prove the feudal structure of the political and economic life of India before the Muslim period do not always clearly express their opinion as to whether the Indian polity during later medieval period extending from the 13th to the early 19th century could also be characterized by a concept of feudalism, although the late Prof. Kosambi has certainly affirmed the point.⁵

Discussion in the light of a concept of feudalism has hardly started regarding the later medieval period of Indian history though some scholars like James Tod regarded long ago the structure of Rajput states in Rajasthan as a specific kind of feudalism,⁶ whereas some historians like Dr. Irfan Habib seem cautiously to avoid any use of it.

Whether the later medieval Indian polity is to be understood in terms of a concept of feudalism or something else, some scholars have pointed out the then wide prevalence of corvée requisitioned by political authorities from subjects in various parts of India,⁷ along with exactions of regular revenues, tributes, and miscellaneous dues. But to the best of my knowledge the exact position of this custom of forced labour has not yet been studied for any part of India during the period.

Accordingly this paper of mine is an attempt at exposing the position of forced labour as it was practiced in the directly administered regions (*svarājya*) of the 18th century Maratha Confederacy on the basis of about fifty contemporary records collected from various Marathi source-books that will be duly indicated in the notes attached at the end of this paper.

This paper will focus attention among others, firstly, on the relationship between the forced labour and the caste system, and secondly on the freedom of people to migrate in the light of exactions of revenue, and so on.

Now before starting discussion a few remarks should be made regarding miscellaneous points connected with the topic.

First, the corvée as practiced in the 18th century Maratha

⁴ S. K. Maity : *The Economic Life of Northern India in Gupta Period* (Cir. A.D. 300-550), Calcutta, 1957, pp. 152-54. U. N. Ghoshal : *Hindu Revenue System*, Calcutta, 1929, pp. 39, 40, etc.

⁵ D. D. Kosambi : op. cit., pp. 338 ff.

⁶ J. Tod : *Annals and Antiquities of Rajasthan*, London, 1st ed., 1829-32, reprint 1950, Vol. I, "Sketch of a Feudal System in Rajasthan."

⁷ E.g. J. N. Sarkar : *Mughal Administration*, 4th ed., Calcutta, 1952, p. 88. I. Habib : *The Agrarian System of Mughal India*, Asia Publishing House, 1963, pp. 150, 167, 239. K. P. Mitra : "Begār or Forced Labour in Historical Records," *Proceedings of Indian Historical Records Commission*, Jaipur, 1948, Vol. XXIV, pp. 26-27.

svarājya was called either *begār* (a Persian term), or *veṭh* (derived from Sanskrit *viṣṭi*), or compound of the two terms, *veṭhbegār*.

Second, about fifty records referred to above extend from 1720 to 1787 and cover all the major regions of *svarājya*;⁸ hence they show the wide prevalence of the practice in the kingdom.

Third, the corvée shown in the source materials is that which was exacted from villages, and it is not clear whether cities distinct from villages also bore the regular forced service.

Fourth, not all the people who did not participate in state power were imposed with the forced service. For instance, not only priestly Brahmans⁹ but also secular ones¹⁰ (e.g. landowners) were exempted from it by the government. Besides, Kāsārs (Brassworkers) of Sāsavad region to the south of Poona were also permanently exempt from forced service, though the reason is not clear.¹¹ Other temporary exemption or reduction of it for some specific reasons will be mentioned later.

Fifth, the *svarājya* included temporarily assigned villages (*mokāsā*, *jāgīr*, *saranjām*, etc.) to state bureaucrats as well as permanently alienated villages (*inām*) to Deshmukh (hereditary chief of Pargana), Deshpande (hereditary accountant of Pargana), important temples, eminent priests, distinguished servants of the state and so on. And such villages may have occupied about a quarter of the total number of the villages in the *svarājya*.¹² At any rate they were usually exempt from forced labour to the state, but were bound to bear it for the sake of fief-holders or *inām*-holders as will be occasionally referred to later.¹³

⁸ Regional distribution of the records is as follows : eleven records for Poona, ten for Junnar, eight for Ahmadnagar, six for Konkan, five for Ratnagiri, three for Bassein, two each for Nasik and Satara, one each for Khandesh, Aurangabad, Sholapur and Dharwar.

⁹ C. V. Vād & D. B. Parasnis ed. : *Selections from the Satara Raja's and the Peshwa's Diaries* (abbreviated as SSRPD in the subsequent notes), Poona, 1906, Vol. II, No. 328.

¹⁰ *Ibid.*, Vol. III, No. 341.

¹¹ *Ibid.*, Vol. I, No. 281.

¹² In Ahmednagar Collectorate, for instance, there were 527 assigned villages out of total 2647 villages at the commencement of British period. *Inām* villages numbered at 156.5. Thus assigned villages and *inām* ones occupied about 20% and 6% respectively of the total number of villages in the Collectorate. Vide W. Chaplin : *A Report Exhibiting a View of the Fiscal and Judicial System of Administration Introduced into the Conquered Territory above the Guts, under the Authority of the Commissioner in the Dekhan*, Bombay, 1824, reprint 1877, p. 17.

¹³ For *mokāsā* villages see SSRPD, Vol. II, No. 284 ; Vol. III, No. 334 ; and for *inām* villages see *ibid.*, Vol. II, No. 285 ; Vol. VIII, Nos. 1090,

And sixth, the general aspects of revenue system in this kingdom have been studied by S. N. Sen,¹⁴ and this paper will make a mention of it only when necessary. It should be borne in mind here that peasants had to pay to the government a heavy land revenue sometimes amounting to the probably highest rate of two-thirds of gross-produce.¹⁵ Besides, artisans and merchants residing in villages, not to speak of towns and cities, had to pay to the government business-tax called *mohatarfa*, and both peasants and village-artisans were bound to bear beyond those regular revenue and tax various small dues in kind or in cash to government, local bureaucrats (such as *Māmlēdārs*, *Kamāvisdārs* and *Khoṭs*), as well as to the indigenous hereditary officers like *Deshmukhs* and *Deshpandes*. In other words corvée was exacted not in lieu of but in addition to such regular and irregular collections, usually in the peasants' slack season from October to March.

II

Corvée and Caste System

We will first examine kinds and amounts of forced labour and then try to find out connection between it and the caste system on the basis of thirty out of fifty records, that are rather concrete in their contents.

Kinds of Corvée

The thirty records may be itemized on the basis of various kinds of services as follows :

- Item A.* Seven records pertaining to corvée exacted for construction or repair of forts (*killā*), police-stations (*thānā*), residences of local bureaucrats, as well as the dams (*dharan*) for irrigation.
- Item B.* Six records regarding portage (*hājir begār*) of grains, timbers and other goods of government.
- Item C.* Five records pertaining to corvée in cutting fodder (*gavat*) at government meadows (*sarkārchā kuran*) scattered in various places.

- Item D.* Five records concerned with miscellaneous labour (*rābaṇūk* or *rābate*) at the local as well as the central government offices.
- Item E.* Two records related to miscellaneous labour and saddlery at government stables (*hujūr pāgā*).
- Item F.* One record on free service of watchmanship (*baithak veṭhbegār* or *chokī veṭhbegār*) at market places (*bājār*).
- Item G.* Four records on forced labour in *inām* villages ; three of them on construction of houses and one on portage for the sake of *ināmdār*.

Above itemization clearly shows that government imposed various kinds of forced labour upon the people both in the centre and in the countryside. It also may suggest that corvée was hardly used for the cultivation of state lands as well as the directly managed lands or demesne of *ināmdār* in his *inām* village,¹⁶ such lands being usually cultivated by share-croppers (*vātekarī*, *ardhelī*, etc.) or on a fixed rent.¹⁷

Amount of Corvée

The amount of corvée requisitioned for construction and repair of forts and so on in Item A does not seem to have been pre-fixed for each village per annum. Rather, government seems to have pressed people into service for the required periods such as eight days or fifteen days¹⁸ whenever it was needed unless it disturbed their occupations.¹⁹ Case was the same with forced labour exacted by holder of an *inām* village from his villagers in Item G above.²⁰

In the case of portage as shown in Item B, also, there seems to have been no fixed rule for its amount ; people were pressed

¹⁶ In this kingdom a part of the village lands was often given in *inām*, apart from *inām* villages. In my knowledge this is the only instance in Junnar region where the cultivation of such an *inām* land in a village was carried out by means of forced labour of the villagers. In this case, though it is not clear who was the *ināmdār*, villagers cultivated the *inām* land by corvée in addition to free contribution of 17,000 bundles of fodder to government, which admitting the excessive exaction of forced labour exempted them from the fodder-contribution for a year. Vide SSRPD, Vol. II, No. 285.

¹⁷ Regarding the cultivation of state land and *inām* land by the tenants, see my essay : "Lands and Peasants in the Eighteenth Century Maratha Kingdom," *Hitotsubashi Journal of Economics*, June 1965, Vol. 6, No. 1, pp. 52-54, 56-60.

¹⁸ SSRPD, Vol. II, No. 286.

¹⁹ Government postponed or reduced the requisition of such forced labour during the busy farming season. Vide *ibid.*, Vol. VIII, No. 1088.

²⁰ *Vaidya Daftar*, op. cit., Vol. IV, (1741); No. 17, (1745); No. 4.

1091. S. L. Vaidya ed.: *Vaidya Daftarāntūn Nivadlele Kagad* (abbreviated as *Vaidya Daftar* in the subsequent notes), Poona, Shaka 1873, Vol. V (1752-53), No. 2.

¹⁴ S. N. Sen : *Administrative System of the Marathas*, Calcutta, 1923 (2nd ed. 1925), Book II, Chaps. V & VI. This book, however, does not refer to the forced labour.

¹⁵ SSRPD, Vol. III, Nos. 327, 334.

into service by central as well as local government as occasion called, though it seems that villagers of a certain village were not engaged in the service continuously for a long distance, but hands were changed at the next village.²¹

In the case of free service to cut fodder for government, amount of the annual (*sālābād*) obligation appears to have been fixed for each district and then for each village (probably from 10,000 to 50,000 bundles per year per village depending on the size of the village).²² And villagers probably used to spend about fifteen days every year for cutting the fixed amount of fodder²³ and had to carry them to the appointed nearby stables of the government.²⁴

In the case of miscellaneous labour at central and local government offices as shown in Item D, the required amount of labour was not fixed beforehand; duration of service varied from fifteen days²⁵ to two months²⁶ per annum in different regions.

The period of service in miscellaneous labour and saddlery at government stables as shown in Item E is only mentioned as 'per last year' (*sālgujastapramāṇēn*).²⁷ But as we shall point out later, service of this item was borne by the same castes (*jāti*) as that of Item D referred to above, we may say that the duration of forced labour in Item E was also from fifteen days to two months per annum.

Amount of corvée in watchmanship at market places as referred to in Item F is by no means clear.

At any rate it should be borne in mind that excepting Item G concerned with *inām* villages, the duration of service such as eight days, fifteen days or two months as shown above was that which central government demanded or sanctioned. As a matter of fact, more arbitrary exaction of forced labour was often practiced by local authorities, and people faced with the excessive demand of corvée sometimes petitioned to central government to reduce or stop it or simply ran away. What central government would do in such occasions will be referred to later.

²¹ SSRPD, Vol. I, No. 365; Vol. III, No. 412; Vol. VIII, No. 1090.

²² *Ibid.*, Vol. VII, No. 741. But the obligation of a certain village, for example, was so changed from 14,000 bundles in the year 1763 to 13,500 bundles ten years later that annual burden of each village may have varied according to the change in the size of its population, for instance. Vide *ibid.*, Vol. VIII, No. 1087.

²³ *Ibid.*, Vol. II, No. 288.

²⁴ *Ibid.*, Vol. VIII, No. 1089.

²⁵ *Ibid.*, Vol. VI, No. 723.

²⁶ *Ibid.*, Vol. III, No. 334.

²⁷ *Ibid.*, Vol. III, No. 265; Vol. VI, No. 673.

Corvée and Caste System

Here we will begin with the corvée in portorage (Item B) and cutting fodders (Item C). People who were engaged in such services are simply called either 'forced labourer' (*begārī*, *veṭhī*, *veṭhbegārī*), 'men' (*asāmī*), or *rayat* (or *rayet*) in our records. As is known, the term *rayat* means 'people' or 'subjects' in general and 'peasants' in particular: at any rate it is not the name of any specific caste. Accordingly we may infer that the corvée in portorage and cutting fodder was not imposed upon any specific castes but upon the villagers as a whole whose main body was peasantry.

On the other hand, it is not clear what kind of people bore the service of watchmanship at market places (Item F).

The situation in regard to construction and repair (Items A and G), miscellaneous labour at government offices (Item D) and miscellaneous labour and saddlery at stables (Item E) is, however, very remarkable in connection with the caste system. In these items certain specific castes are clearly pointed out in the records as those who have been requisitioned in the different services: the *Sutārs* (Carpenters), *Kumbhārs* (Makers of pots and bricks), *Pāṭharvaṭs* (Masons), *Gavaṇḍī* (Bricklayers) along with the forced labourers (*veṭhīs*) and *rayats* in the case of construction and repair of buildings and dams (Items A and G);²⁸ *Mahārs* (untouchable caste engaged in miscellaneous menial labour such as sweeping the dirt and removing the dead animals, and so on) in the case of miscellaneous labour (*rābaṇūk* or *rābate*) at government offices (Item D) and stables (Item E);²⁹ and *Chanbhārs* (untouchable caste occupied with leather works), *Māngs* (untouchable caste of rope-makers), and *Jingars* (untouchable caste specializing in making bridles and saddles among the leather works) in the case of saddlery at government stables (Item E).³⁰ In these items not only the names of specific castes are mentioned but also the number of persons to be requisitioned from each district or from each village is also often specified in our records.

The fact that various artisan castes and untouchable ones were regularly pressed into forced service in their respective traditional occupations by the government or by the privileged holders of villages either in fief or in *inām* suggests an important financial

²⁸ SSRPD, Vol. II, Nos. 196, 286; Vol. III, No. 315. *Vaidya Daftar*, Vol. IV, (1741); No. 17, (1743); No. 17, (1745); No. 4. R. V. Oturkar ed.: *Peshvekālīn Sāmājik va Ārthik Patravayavahār*, Poona, 1950, No. 89.

²⁹ SSRPD, Vol. II, No. 283; Vol. III, Nos. 265, 334, 415; Vol. VI, Nos. 673; 723.

³⁰ *Ibid.*, Vol. III, No. 265; Vol. VI, No. 673.

role played by caste system in the total polity of Maratha Kingdom : the caste system did not only maintain a considerable self-sufficiency of services *inside* the village, but also was closely connected with and utilized by the authorities through the system of forced labour.³¹

III

Corvée and Freedom of People

Basic Attitude of Government towards Corvée

People who bore all these burdens were necessarily to be protected by central government. And in fact the government seems to have always been cautious to see to it that people should not be 'harassed' (upadrav) or 'abscond' (parāgandā) because of excessive demand of revenue, corvée and so on. But the demand of corvée by local bureaucrats and their subordinates tended to be so heavy that people sometimes resorted to absconding. In such cases the central government would command the local bureaucrats to reduce the demand down to the customary standard and levy the corvée only so much as required for the government works and with a due consent of hereditary officers of the place.³² And on the other hand government would order the headman of the village to induce those who had absconded to come back to their village.³³ There were such cases also that when people in a service of portage ran away on the way, the government imposed a certain amount of money upon their village and employed wage-labourers (*majūrdār*) in their stead.³⁴ Even when people did not run away but simply complained about excessive demand of corvée, government would accept the appeal and allow the people to pay a certain amount of money in lieu of the corvée,³⁵ although such a measure does not seem to have become perpetual but rather appears to have reverted to ordinary provision of labour after some years.³⁶

Government did not only occasionally allow the money-pay-

ment of corvée, but also specially reduced or cancelled the corvée of the year from those masons, bricklayers and so on, who were then incidentally employed in the construction of some donated temple, as well as from such villages as had been recently damaged by the army or had just entered the busy agricultural season.³⁷

Moreover, not all the corvée was unpaid : people requisitioned in miscellaneous labour, at least, were sometimes provided with a small amount of money or grains by the government.³⁸

In short it seems that the *principle*, as it were, of the central government was not to exact as much corvée from the people as possible but to impose it upon them 'properly' (*shist*), namely 'according to the custom' (*shirastpramāṇen*) and to that extent to which central government demanded or sanctioned.³⁹

Freedom of People

As pointed out above, when people ran away due to some grievances, government tried to induce them to come back. Then were the people *legally* bound to a certain fixed region or village ? Or were they able to migrate to other places on their own will even in opposition to the wish of the government ?

To be sure I have not been able to find any evidence to show that people actually migrated to other places merely because of the excessive demand of corvée. There are, however, several interesting records which show that people migrated *en masse* to other places due to a difference of revenue burdens between different regions. Out of them the most informative will be translated as follows :

The Secretariat (Chitnisi) of Poona government issued following order to a bureaucrat posted at Nasik District in December 1779.

"Govind Ram, the Governor (Māmlēdār) of Kalyān Bhivandī District reported early this year to government as follows : 'Whereas in the regions of Deher Borath and Korakdā of Kalyān Bhivandī District, survey (*pāhaṇī*) was done in the suhūr year 1172 (= A.D. 1771), and Trimbak Vināyak (name of an officer) settled the revenue (*jamābandī*), peasants (*kulēn*) so surveyed have however left for the regions of Trimbak and Ratangad (of Nasik District), so that the above two regions (of Kalyān Bhivandī) became ruined, and a loss

³¹ Cf. My Essay : "State and Caste System (Jāti) in the Eighteenth Century Maratha Kingdom," *Hitotsubashi Journal of Economics*, June 1968, Vol. 9, No. 1, p. 44.

³² "... *veṭh bigār sarkārāmās agatyāgatya lagel, tī jamāndārāche gujāratīneṣh shist karūn gheṇen*" (SSRPD, Vol. VI, No. 716). Also *ibid.*, Vol. VI, No. 723.

³³ *Ibid.*, Vol. VI, No. 735 ; Vol. VII, Nos. 429, 431.

³⁴ *Ibid.*, Vol. VIII, No. 1092.

³⁵ *Ibid.*, Vol. II, No. 283 ; Vol. VII, No. 741 ; Vol. VIII, No. 1089.

³⁶ *Ibid.*, Vol. II, No. 283 ; Vol. III, No. 415.

³⁷ *Ibid.*, Vol. II, No. 196 ; Vol. VIII, Nos. 999, 1087, 1088.

³⁸ *Ibid.*, Vol. II, No. 282 ; Vol. VI, No. 723.

³⁹ *Ibid.*, Vol. III, No. 421. Oturkar : *Peshvekālīn Sāmājik va Ārthik Patravayavahār*, op. cit., Nos. 6, 88.

to government took place.' Accordingly government already issued following letter to you, 'Send back above peasants to their respective regions, or collect the revenue (*dhārā*) from these peasants in your own regions according to the rate that would be fixed by the Governor of Kalyāṇ.' Nevertheless you did not do so, but simply issued letters to your own Collectors (*Kamāvisdārs*) to the effect that peasants should be sent back if they so agreed (*rajāband*). Therefore officers subordinate to Governor (*Māmledār*) of the above District (Kalyāṇ Bhivandī) have again petitioned to the government as follows, 'Why would the peasants agree to come back, for those peasants who had been cultivating land here at the rate of Rs. 50 are cultivating the same amount of land there at the rate of Rs. 25? When the said peasants newly migrated there the Collectors of the places easily issued assurance knowing that they (Collectors) would also be benefited. Then how would the peasants agree to come back? . . . Therefore please issue an order on this matter.' Accordingly this order-letter is issued to you. When some ones come there to take those peasants back to their respective regions who have migrated from above two regions of the above District (Kalyāṇ Bhivandī) to your regions, issue a strict order (*tākīd*) to them to be taken back. If the peasants do not want to go back, collect revenue (*vasūl*) from each one of them according to what Governor of Kalyāṇ will fix as the assessment upon the peasants on the basis of the survey done in suhūr year 1172. You must not cause the complaint to occur again on this matter."⁴⁰

⁴⁰ Ibid., Vol. VI, No. 744. "Pargane Deher Goraṭh va Tāluke Korakḍā, Prānt Kalyāṇ Bhivandī, yethil san isnain sabainānt pāhanī hoūn, Trimbak Vināyak yāññiñ jāmabandī ṭharaulī, tyā pāhanīntil kuḷeñ, Trimbak, va Ratangad, Tālukyānt gelīñ āhet, yājmulēñ he donhī mahāl kharābpaḍon sarkārnuksān jāleñ, heñ vartmān sālmaṅkulīñ Govind Rām Māmledār, Prānt majkur, yāññiñ sarkārānt nivedan keleñ tyājvarūn tuhmāns patreñ sādār jāliñ kīñ, sadārhu kuḷeñ mahālche mahālīñ pāthavneñ, nāhiñ tar tyā kulāñchā dhārā Kalyāñche Māmledār bāndhūn detil, tyāpramāneñ tuhmīñ āple Tālukiyākaḍe jamā dharneñ, aseñ astāñ tyāpramāneñ na keleñ; āpi tuhmīñ āple kaḍil kamāvisdārāns patreñ kuḷeñ rajāband karūn netil tiñ neūñ deñeñ, yāpramāneñ patreñ dilhiñ, tyās kuḷāche rajābandichā prakār tarī, jeñ kṛl prānt majkurīñ pannās rupayāñche jitkī jamīn karit hoteñ teñ kṛl tikḍe jāūn titkī jamīn pañchvis rupayānt kariteñ. ukteñ kṛl tikḍe naveñ jāteñ teñ tikḍil kamāvisdārās naphyānt mīṭeñ, heñ jāñon sahal kaul detāt, tevhāñ kṛl rājī hoūñ kaseñ yeil? donhī Tāluke sarkārche; yājkaritāñ yevishīñ ādnyā jāli pāhiye; mhañon Prānt majkūrche Māmledārākaḍil kārku-nāñmīñ Hujūr vināñti kelī, tyājvarūn heñ patra sādār keleñ ase, tarī Prānt majkūrche donhī mahālāntil kṛl tuhmāñkaḍil hardū Tālukiyānt

The record translated above fairly clearly shows at least following two points. First, people⁴¹ could migrate to other areas if they wanted to do so, even against the will of government. In other words they were not *de jure* bound to a certain specific area or village, but had a freedom of migration *in principle* so far as they performed their duty of paying revenue and so on to the authorities. More generally speaking, it appears that there was no legal status of *serfs* in this kingdom, all the people being free in principle excepting slaves who were unfree *de jure* as well as *de facto*.⁴² Second, above record shows, however, that both central government and local bureaucrats obstinately desired to promote the people to return to the areas or the villages wherefrom they had absconded.

Why did not government leave the people to migrate and satisfy itself with taking the revenue and so on from them at the new place wherein they had settled? Why did it so strongly demand them to return?

There seems to have been two major reasons for that. The first lay in the systems of revenue collection of this kingdom. Broadly there were two systems of revenue collection; collection through formal Collectors (*Kamāvisdārs*) and that through revenue Farmers (*Khoṭs*). In the *khoṭi* system, when farmers were unable to collect the contracted amount of revenue due to absconding of peasants or some other reasons, they were obliged to 'fill up' (*bharneñ*) the deficiency on their own account unless they were specifically exempted from it by government.⁴³ In the case of *kamāvisdārī*, though the Collectors were not always obliged to fill up the deficiency from their own pockets, yet they were usually bound to pay to the government in advance a considerable portion of the revenue to be collected from their jurisdiction, and the remuneration for them also often consisted

getiñ āhet, tiñ mahālche mahālīñ āntil, tyāns tākīd karūn lāun deñeñ kuḷeñ yet nasliñ tarī, isanneñt pāhanī jāli āhe, tyāpramāneñ Kalyāñche Māmledār tyā kuḷāchī jamā bāndhūn detil, tyā bamojib kuḷāragavār jamā dharūn, vasūl gheñeñ. (ye)vishīñchā bobhāt phiron yeūñ na deñeñ.

⁴¹ The record translated above refers to peasants (*kuḷeñ*), but other records of similar purport are concerned with people in general (*rayat*), so that the above record may be understood to apply to the people in general. Vide *ibid.*, Vol. III, Nos. 372, 375.

⁴² On the position of male and female slaves in this kingdom who were employed mostly in domestic services in the courts and more or less well-to-do families, see my Japanese essay: "Gulām and Kunbiṇa in the 18th Century Maratha Kingdom," *The Hitotsubashi Review*, June 1961, Vol. 45, No. 6.

⁴³ SSRPD, Vol. VI, Nos. 716, 762.

of a certain proportion of the revenue assessed therefrom.⁴⁴ Therefore it was very important for either of them to cause as many people as possible to remain and work in their respective jurisdiction which was sometimes composed of single village. The second reason is to be found in the vested interests held by indigenous privileged class called *hakkdārs* such as Deshmukhs, Deshpandes, Patils (hereditary headmen of villages), Kulkarnis (hereditary accountants of villages) as well as temples, priests and so on. All of them were entitled to receive a certain amount of produce from people of the region or the village.⁴⁵ Therefore it seems to have been necessary for the government to maintain and promote the settlement of the people in a certain specific area and village in order to protect the vested interests of the privileged class, whereas the government at the same time ought to have taken into consideration the welfare of the people as mentioned before.

Thus it may be said that *de jure* free status of ordinary people was *de facto* restricted more or less by the politico-economic interests of the ruling classes extending from village *hakkdārs* up to central government, and they were *actually* more or less bound to a certain specific region and village.

Mechanism for Enforcing the Corvée

In a government village as well as in an alienated one it was usually headman of the village (Patil) who was held responsible at the bottom of administrative hierarchy to maintain and promote the settlement of people and procure annual revenue, cesses and corvée from them.⁴⁶ Being always in the intermediate position between government authorities and people, he would complain to government of excessive demand of revenue and corvée, request it to reduce or exempt it,⁴⁷ and sometimes resort

⁴⁴ Though we can show a large number of records regarding the *koṭhī* and *kamāvisdārī* systems, suffice it here only to refer to *ibid.*, Vol. III, Nos. 406, 407, 427, 430; and also to S. N. Sen : *Administrative System of the Marathas*, op. cit., 1st ed., pp. 219-21.

⁴⁵ Although records on these privilege-holders are also large in number, suffice it here to refer to S. N. Sen : *ibid.*, pp. 183-95, 211-18; and also to S. N. Joshi : "Deshmukhi Watan," *Aitihāsik Sankīrṇa Nibandh*, Poona, 1943, Vol. I, pp. 60-75; Do. : "Chaugulā," *ibid.*, Poona, 1947, Vol. II, pp. 28-33.

⁴⁶ Deshmukh and Deshpande, hereditary chief and accountants of a Pargana respectively were not more than to help as well as check the local bureaucrats and were not *directly* responsible for collecting revenue etc., and requisitioning corvée in the 18th century Maratha *svarājya*. Vide S. N. Sen : op. cit., pp. 211-17. SSRPD, Vol. VI, Nos. 716, 723.

⁴⁷ *Ibid.*, Vol. III, No. 334; Vol. VI, No. 714.

to absconding along with villagers.⁴⁸ On the other hand, however, it was he who would deal with local authorities and undertake to procure necessary corvée for them,⁴⁹ and indeed there were some Patils who had their revenue-free lands (*inām jamīn*) augmented by government as a special reward for their distinguished service in providing it with required corvée.⁵⁰ But unfortunately we are unable at present to make it clear how the village headman allotted burden of corvée among his villagers.

IV

Conclusion

Although the scope of our discussion has been limited to the 18th century Maratha *svarājya*, the following points among others may have been made fairly clear : First, there was a strong financial connection between Maratha polity and caste system through the regular requisition of forced labour from artisan and menial castes by the authorities. Second, the people had their *de jure* liberty of migration more or less restricted *de facto* by the government because of the specific revenue systems on the one hand and the vested interests of privileged class on the other. And third, the institution of village community was utilized by ruling powers as the compulsory mechanism for procuring revenue, cesses and corvée.

When Maratha *svarājya* was annexed to British territories in 1817-18, the basic principle of the government of East India Company was to do everything possible 'to reassure people concerning the new government'.⁵¹ As a result the government abolished corvée system to be used for government works, and in its stead levied from every government village a certain amount of money for fodder (*gavat begār*) and for miscellaneous labour (*rābaṇūk*).⁵² But corvée continued to be often requisitioned by low-class officers and soldiers of the government so that it had frequently to prohibit the abuse.⁵³ On the other

⁴⁸ *Ibid.*, Vol. III, No. 372.

⁴⁹ *Ibid.*, Vol. I, No. 366; Vol. VI, No. 741.

⁵⁰ *Ibid.*

⁵¹ K. Ballhatchet : *Social Policy and Social Change in Western India, 1817-1830*, London, 1957, p. 10.

⁵² W. Chaplin : *A Report Exhibiting a View of the Fiscal and Judicial System of Administration, etc.*, op. cit., pp. 139, 143.

⁵³ R. D. Choksey ed. : *Period of Transition (1818-1826)*, Poona, 1945, pp. 101-102, 200-207.

hand, government connived at the exaction of forced labour by indigenous privileged class such as Deshmukhs, Deshpandes, *ināmdārs*, and so on for a long period of years. It was in 1860 that the government formally prohibited all sorts of forced labour as practiced in British India. The Indian Penal Code enacted in the year declared, 'whoever unlawfully compels any person to labour against the will of that person, shall be punished with imprisonment of either description for a term which may extend to one year, or with fine, or with both'.⁵⁴ Although private exaction of forced labour seems to have been occasionally practiced even after the promulgation of the Code, we may still observe in the provision one of the important aspects of transition from medieval to modern period in Indian history.

Though socialists in India, including Marxists, have been critical of the economic policies of the Government of India, they have generally welcomed the formation of the state sector and have seen in its expansion the strengthening of our economy. However, the results of economic planning, the farce of the Fourth Five-Year Plan, the dominance of big business and the growing hold of foreign capital on our economy suggest that we reformulate our ideas on the nature of economic planning in the country and on the role of the state sector rather than issue appeals to the Establishment for "rethinking". The following paper makes an effort to indicate some of the issues which need to be enquired into for a fresh understanding of the nature and impact of the state sector in India.

Before we discuss these issues some comments are required on the use of the term State Capitalism. This is essential for conceptual clarity. Many writers, including certain Marxists, have used the term to designate the existence of a significant state sector within a capitalist framework of economy and have distinguished it from purely private-enterprise capitalism. There does not seem to be any justification for this distinction. These are not two different categories of capitalism; the state-ridden capitalism is only an outgrowth of free-enterprise capitalism and retains its basic features. Western capitalism has experienced increasing intervention and direct participation of the state in economic activity, also earlier, but particularly since the Second World War.¹ The original purely private-enterprise model has

* This is the revised version of a paper presented at the First All-India Conference on Marxian Approach to Research in Social Sciences, organised by the Indian School of Social Sciences, Trivandrum, June 5-9, 1969.

¹ Such a state sector arises out of the economic needs of the bourgeoisie itself, and not in order to assuage the socialist consciousness of

⁵⁴ H. S. Gour : *The Penal Law of India*, Calcutta, 1910, Vol. II, Section 374, pp. 1453-54.

lost its significance in the recent period.

Lenin himself applied the term state capitalism to the stage of transition between capitalism and socialism in the U.S.S.R., i.e. the period broadly covered by the New Economic Policy. But he gave it an entirely new connotation. "With us it is not the bourgeoisie but the proletariat which rules the state. State capitalism in our case means capitalism which we shall know how to restrict and to which we shall be able to set limits. . . . It is that capitalism which we must circumscribe." (*Principal Tasks of Our Day*, 1918.) In his various writings and speeches he made it clear that it would be a "transitional period" during which elements both of capitalism and socialism would co-exist; but the "commanding heights" of the economy would be controlled by the proletarian state. This transitional state capitalism was necessary because the working class, though it held political power, had yet to acquire the technological knowledge and skill necessary to run the modern industry.

My fear is that if we use the term state capitalism indiscriminately to describe the existing state sector in India we might fall into the error of ascribing to it many of the features embodied in the state capitalism of Soviet Russia of the twenties, i.e. we might over-emphasise the "progressive role" of the state sector; or we might think that the expanded state sector will facilitate the transition to socialism once the political power passes into the hands of the working class.² In the light of the past Marxist-Leninist analysis and the Indian experience of the working of the state sector both these positions seem to be incorrect.

A shift is in fact discernible in the Marxist opinion in India in regard to the nature and role of the state sector during the last decade or so. The Amritsar Congress of the Communist Party (1958) had welcomed the formation of the state sector as a "progressive measure" and in its Resolution on National Campaigns allotted the first place to "Realisation of the targets of the

people. It is, therefore, difficult to agree with E. M. S. Namboodiripad when he says, "Big business, however, knows that it would be extremely unrealistic to expect the policy of nationalisation to be completely given up. After all, this is an epoch in which the influence of socialism as an ideology is being felt throughout the world; India therefore cannot be an exception to it." (*Economics and Politics of India's Socialist Pattern*, p. 195.)

² Cf. for example, the remarks of Paresh Chattopadhyaya: "It must, however, be stressed that the development of State Capitalism is objectively a step forward compared to purely private enterprise capitalism in that by creating a necessary material base, it facilitates the transition to socialism once the working class seizes the political power. (*Alternate Policies for the Fourth Five Year Plan*, Trivandrum 1969, p. 74.

plan in a democratic way". The Sixth Congress of the Communist Party (1961) in its document "New Situation and Our Tasks" noted that the formulations of the Madurai Programme of the Party "could not explain Bandung, they could not explain the Second Five-Year Plan."³ But the programme adopted by the Seventh Congress of the Communist Party (Marxist) 1964 is based on a different understanding. "The actual realities" it says, "show that the state sector itself in India is an instrument of building capitalism and is nothing but state capitalism."⁴

It is these "actual realities" of the Indian economic situation that need further enquiry and analysis.

The origins of the state sector in India were not based on nationalization of any basic industries. Nationalization of air transport, of Imperial Bank and of life insurance, guaranteeing partial preservation of rights and payment of full compensation, has very little significance from the point of view of bringing about structural changes in the economy as these were not concerned with the production proper.

The Congress Economic Programme Committee had envisaged nationalization of existing capitalist undertakings within a period of five to ten years after Independence. The Industrial Policy Resolution (1948) was a retreat from this position as these undertakings were now to be allowed facilities for expansion and efficient working. Nationalization was to be used, if at all, "as an expedient for increasing production, not a means for attaining a measure of social justice, or a different order of society."⁵

As a result of virtual rejection of a policy of nationalization of industrial enterprises the capital for newly created enterprises within the state sector has had to come from the people through the channel of taxation and deficit financing. Through heavy reliance on indirect taxes the lower and middle income groups have been burdened further.

It is true that an underdeveloped country has to pass through a period of great sacrifices to accumulate capital for industrial construction, more so since it has to invest a large proportion of its savings in heavy industry which requires a longer period of gestation, and the returns are small in the beginning. The sacrifices would become economically unjustifiable and intolerable if inefficiency and corruption prevail in state enterprises as is the case in India today. According to the annual report on the working of industrial and commercial undertakings of the Central Government for 1967-68, the overall performance of these under-

³ *New Situation and Our Tasks*, 1961, p. 13.

⁴ *Programme of the Communist Party of India*, 1964, p. 8.

⁵ M. Kidron, *Foreign Investments in India*, 1965, p. 85.

takings during the period shows a net loss of Rs. 35.23 crores as against the loss of Rs. 10.18 crores during the previous year.⁶ The state sector is thus indulging in reckless squandering of public funds.

The more positive impact of the state sector on the economy has been in the building up of economic and social overheads. A major proportion of plan expenditure has gone not into industrial investment but into the strengthening of transport, communications, generation of electricity, technical education, etc. This pattern of expenditure, by providing indirect subsidies, has greatly benefited the private sector and has pushed up the rate of profit on private capital.

The state sector is also encouraging monopolistic concerns through its policy of supplying them with raw materials at rates cheaper than the actual market rate (for example the sale of state sector steel at low prices).⁷ The purchase policy of the state sector also works in a similar manner. Large firms have direct contacts with decision-making bodies and are given preference over smaller units. Apart from the contacts which monopolies have with the bureaucratic machinery of the state sector and the interlocking directorships between the private and the state sector,⁸ the state sector finds it more convenient, in the interest of efficiency, to place its orders not with scattered but regular and fewer sources.

No less significant is the role of the state sector as a financier of the private sector, especially of the big monopoly groups. According to a recent study undertaken by the *Economic Times*, the state sector financial institutions have become the premier underwriters for the capital issues of limited companies. The proportion of the capital issue underwritten by these institutions to the total amount underwritten rose from 37.7 per cent in 1962 to 71.2 per cent in 1968; in terms of the total net issue, the proportion rose from 28.3 per cent in 1962 to 70.7 per cent in 1968.⁹ Moreover, as the Industrial Licensing Policy Committee noted recently, the underwriting institutions had to bear a comparatively higher percentage of the underwritten amounts in the case of the larger industrial houses, because the market did not

subscribe fully to the flotations. As for direct investment, the Life Insurance Corporation was committed from the beginning to support the private sector. Figures recently laid before the Parliament (16 May, 1969) make instructive reading. Out of Rs. 212 crores invested by the LIC in the private sector Rs. 134.89 crores or about 64 per cent has been invested in the 75 groups listed as monopolies by the Monopolies Commission. Out of this, the top ten monopoly groups account for Rs. 57.41 crores or about 27 per cent of the LIC's total investment in the private sector.

The recent nationalization of the fourteen major banks is a welcome step, but it is yet to be seen whether the credit policy of the nationalized banks will in practice be any different from that of the other state sector financial undertakings.

The Government's 'licensing policy', which is supposed to impose controls for the purpose of expansion in high-priority industries, has in practice been used by the big monopolies to exclude competition and pre-empt capacity in various industries.¹⁰ This has been shown in convincing detail by the Industrial Licensing Policy Committee whose report, covering the period 1956-66, was released recently. It has been noticed by the Committee that in the actual grant of licenses it is not only the medium and small business which is excluded from entering and expanding into various industries but the state sector undertakings also find themselves in the same position, being denied licenses, while the big business pre-empts future industrial capacity.¹¹

Another very significant problem which needs further investigation is the relationship between the state sector and foreign capital and the wider implications of this relationship. The understanding that "state capitalism" in an underdeveloped country, "may be progressive, at least in so far as it enables the country to fight for and consolidate its independence *vis-a-vis* imperialism",¹² is not borne out by the Indian experience. Soon after independence the initial misgivings on the role of foreign capital were discarded. (It is interesting to note that the private sector

⁶ *The Hindustan Times*, 14 May, 1969.

⁷ "Thus when put into practice, the vaguely socialist notion that public enterprises must render services at low prices in fact boosts considerably the returns on private capital." (Gunnar Myrdal, *Asian Drama*, II, p. 819).

⁸ For a fuller discussion, see E. M. S. Namboodiripad, *Economics and Politics of India's Socialist Pattern*, p. 197.

⁹ *The Economic Times*, Bombay, May 6, 1969.

¹⁰ This is brought home by the simple fact that in 1966 the large groups accounting for about 8 per cent of the total paid-up capital of limited companies, obtained 38 per cent of the licenses issued to the entire corporate private sector.

¹¹ For a very interesting discussion of excess capacity creation by the private sector, its financing with government's support, and its use in the argument against expansion of capacity in the state sector, see the paper by S. Ganguli, 'Public Sector and Private Sector: Dynamics of the System' in *Alternate Policies for the Fourth Five-Year Plan*.

¹² Paresh Chattopadhyaya in *Alternate Policies for the Fourth Five-Year Plan*, p. 74.

The Vedantic Thought as Represented in the Dharmaśāstra and the Arthaśāstra

I

Vedānta Thought in the Dharmaśāstra

IN INDIA a great number of law books have been composed since ancient time. They prescribe social systems, customs and daily activities, focusing their attention upon such problems as four castes and the four stages of life (*āśrama*) from the standpoint of Brahmanism. At first they were written in the comparatively concise *sūtra* style and their contents also were brief and simple, but later, detailed law books containing the civil and the criminal laws were also produced. These were compiled and edited by the priestly *Brahmans* and the world view of Brahmanism is clearly seen in them. Among the Buddhist texts the *Vinaya-Piṭaka*, which is one of the *Tripitaka*, should be regarded as a kind of law book, but it is a legal work to be applied only to the order of monks and not to the general society. However, the law books edited by the *Brahmans* carry the banner of being rules and regulations for general society, and are completely different in their significance from the *Vinaya-Piṭaka*. These law books compiled by the *Brahmans* have been regarded as the most valuable materials from which to get information about social conditions in ancient India. On the other hand, however, some scholars assert that these law books are nothing but the fantasies of the *Brahmans* of the priestly class, being quite far from the actual conditions of the real society of ancient India.¹ Therefore, a thorough-going investigation is necessary in order to make clear the historical and social significance of the Brahmanical law books,

¹ See such works as R. Fick, *Die sociale Gliederung im nordostlichen Indien zu Budha's Zeit*, Kiel, 1897 and T. W. Rhys Davids, *Buddhist India*, London, 1902.

harboured these misgivings for a longer period than the Government of India.) The Fiscal Commission in its Report (1949-50) suggested that foreign capital should be confined to projects in the state sector which depend on the import of capital goods and equipment and to those undertakings in the private sector which involve new lines of production.¹³ The next stage was marked by 'collaboration' between foreign and Indian capital, and the state sector became a channel for the flow of foreign investments, loans and 'aid'.

The state sector has also been receiving a significant amount of aid and credit from socialist countries. In welcoming this aid Indian Marxists have often said that aid from socialist world is basically different in character from the aid from capitalist countries because it is earmarked for the construction of heavy and basic industries on which depends the future rate of growth of our economy. But we should also note that socialist countries are developing economic ties with the private sector in India. Russian credit was granted to Hindustan Gas Co.; Hindustan Films, Calcutta, a subsidiary, received technical aid. Other Eastern European countries had entered into 70 collaboration agreements with privately owned firms by the end of 1964.¹⁴ While the socialist economic aid to the state sector implies economic and political support to the present political regime, its flow into private sector means strengthening of the capitalist structure of our economy.¹⁵ I fail to see how Marxists can be happy about either of these consequences.

In regard to the question of relationship between a strong state sector and democracy I would venture to restate the position that the basis of any democracy is the socio-economic system which itself depends on the ownership of the means of production and the production relations of that society.

¹³ M. Kidron, *Foreign Investments in India*, pp. 97-112.

¹⁴ *Ibid.*, p. 116.

¹⁵ This duality in Soviet practice is reflected in the statement in a recent Soviet work that "the main contradiction in independent India, in the view of the author of the present book, is the contradiction between the deformed and backward state of the national economy and the need for speedy and all-round economic progress." (A. I. Levkovsky, *Capitalism in India*, p. 405.) Aid to both the State and private sectors can then be justified in the name of "economic progress".

but I shall not now enter into this problem. What I wish to say is that since these law books are works by the *Brahmans* they are valuable materials which provide information about the thought of the *Brahmans*. It is needless to say that the *Vedānta* thought expounded in them should be highly evaluated as revealing an aspect of the history of the *Vedānta* philosophy.

The *Vedānta* thought appears especially in the *Āpastamba-Dharmasūtra* among the ancient law books. This work has been considered as one section of the *Kalpasūtra* belonging to the *Āpastamba* school, a black *Yajurveda* school in southern India, and it is one of the oldest extant works. In I, 8, 22 and 23 of this work a *Vedānta* thought is explained and this section is in particular called the *Adhyātmapaṭala*. There is also its commentary entitled *Adhyātmapaṭalavivaraṇa* ascribed to Śaṅkara which has been published.² Depending upon this commentary, I shall translate it in the following pages.

The authenticity of this commentary has been called into question.³ But it quotes mostly the ancient *Upaniṣads* and its literary style resembles that of Śaṅkara. Moreover, as a commentary it is far more accurate than the *Ujvalā Vṛtti* of Haradatta which is a commentary on the entire *Āpastamba-Dharmasūtra*⁴ and shows that its author was versed in *Vedic* usage in Sanskrit. These facts may point to Śaṅkara's authorship of the text. Even if it is not an authentic work of Śaṅkara, I would think that it may be treated as his work. In other words it must have been written by a scholar who had the same kind of learning and education as Śaṅkara in a period not too far from him.

² It is also called the *Adhyātmapaṭalabhāṣya*. Minor works of *Shankarāchārya*, ed. by H. Raghunath Bhagavat (Poona, 1925), pp. 422-435. It is also published in the *Trivandrum Sanskrit Series*.

³ Belvalkar, *Shree Gopal Basu Mallik Lectures on Vedānta Philosophy*, Pt. I, (Poona, 1929), p. 219.

⁴ The *Ujvalā Vṛtti* of Haradatta was composed in the 15th century or about one hundred years earlier than that. Though not extant at present, a commentary on the *Āpastamba-Dharmasūtra* was in existence (G. Bühler, *Sacred Books of the East*, Vol. II, Introduction, p. xlvii). There are not a few mistakes in Haradatta's commentary on the *Ādhyātmapaṭala*. For example, Haradatta reads *idam id, iha id, iha loke* (22, 5) as *idam idi, ha idi ha* (Bühler, *op. cit.*, p. 76, n. 5), and this is clearly a mistake and points to the fact that he is not familiar with *Vedic* usage. Śaṅkara however interprets it correctly. Haradatta's note on 22.6 is also unreasonable as Bühler says, but it can be interpreted without much difficulty, if Śaṅkara's interpretation is taken into consideration. Haradatta gives another unreasonable interpretation based on folk-etymology to the eight-fold *viṣṭapa*.

Āpastamba-Dharmasūtra, I, 8, 22

1. One should practice the *yoga*⁵ concerning *ātman*, which accords with reason and does not fluctuate the mind.⁶
2. There is no higher [object] than the attainment of *ātman*.
3. In order [to attain to] that *ātman*, we shall quote those sacred stanzas⁷ which teach the attainment of *ātman*.
4. All living creatures are the castle of that [*ātman*] which dwells in hiding-places, uninjured and spotless. Those who worship⁸ the [*ātman*] which is immovable, abiding in the movable [phenomenal world], become immortal.
5. Abandoning everything which is called the object [of the senses] in this world, a wise man should worship that [*ātman*] which dwells in hiding-places.
6. If one says without attaining *ātman* within himself, "I wish to look for the place [as a clue to] cognizing that good [*ātman*] within the other things," [the teacher tells him], "Serve this advantageous one (*hita*) who is great, whose body is luminous, and who is the lord kept in everything, and not the disadvantageous (*ahita*) without being desirous [of the pleasure of the external world]."
7. He, who is the eternal one in all beings, wise, immortal, constant, devoid of parts, soundless, bodiless, touchless, great and pure, is all and is the supreme goal. He is the centre [of all]. He is the city intersected with many streets.⁹
8. He, who worships it (= *ātman*), who always practices the life of the religious mendicant (*prādhva*)¹⁰ everywhere, and who sees [*ātman*], which is difficult to see, and subtle, with his mind under control, will rejoice in the heaven.

Āpastamba-Dharmasūtra I, 8, 23,

1. The wise man who sees all beings within himself, who does not become deluded while pondering, and who sees himself

⁵ *yogāḥ* = *akrodhādayaḥ* (Śaṅkara).

⁶ *anīścārika niścārayanti mano ntaḥtsham bahirviṣayebhya iti naiścārikāḥ krodhādayo doṣāḥ*, (Śaṅkara).

⁷ Śaṅkara says that they are quoted from the *Upaniṣads* of other schools (*śākhāntaropaniṣadbhyaḥ*). Haradatta says likewise that they are quoted from some *Upaniṣads*.

⁸ *anutiṣṭhanti* = *mamātmeti sākṣāt pratipadyante* (Śaṅkara). But I have followed Bühler's interpretation of the word as worship.

⁹ *vaiḥbhājanam puṣam*. I have followed Bühler's translation based on Haradatta's commentary. Śaṅkara interprets it as "discriminating itself" (*vivekaḥ ātmanah*).

¹⁰ *prādhvam bandhanam ātmaikatvarasaprajñatām, sthīrām bāhyai-śaṇḍavyvṛttarūpām sarvasamnyāsakṣaṇām* (Śaṅkara).

within all beings, is truly a "Knower of *Brahman*"¹¹ and shines forth in the uppermost world of the heaven.¹²

2. He who is the subtler than the thread of the lotus-fibre, keeps on covering all, who is larger than the earth, constant and persists to contain all, is the supreme one, divides himself, different from the knowledge of this world which is identical with the object to be perceived by the senses. All bodies spring from him. He is the root [of the world]. He is eternal and constant.

3. But the destruction of faults results from the *yoga* here in this existence. Having eliminated [the faults] which destroy the creatures, the learned one arrives at peace (*kṣema*).

4. Now we shall enumerate the faults which destroy the creatures.

5. [They are] anger, exultation, wrath, covetousness, delusion, hypocrisy, violence, falsehood, gluttony, slander, envy, lust, secret hatred, neglect to control the senses, and neglect to concentrate the mind. The destruction of these [faults] takes place through the means of *yoga*.

6. Non-anger, non-exultation, non-wrath, non-covetousness, non-delusion, non-hypocrisy, non-violence, truthful words, moderate eating, non-slander, non-envy, the distribution of property, alms-giving, uprightness, kindness, tranquility of the mind, control of the senses, peace [with all beings], concentration of the mind, noble conduct [becoming to an *Aryan*], warm feelings, contentedness—these are [the virtues] which must necessarily be observed throughout all of the [four] stages of life.¹³ He who puts them into practice according to the rules becomes one who goes everywhere.

In the above section *sūtras* 22, 4-23, 3 are quotations from authoritative works prior to the *Āpastamba-Dharmasūtra*. As the commentator says, they may be cited from some *Upaniṣads* which were composed before that time, but cannot be located in the extant *Upaniṣads*. But the following instances are very much like the *Kāthaka Upaniṣad*:

¹¹ *Brahmā*. It is a pregnant expression... See my Japanese translation of *Māṇḍūkya-kārikā* IV, 85, (see note 29 below), Vol. III, 6. Cf. *Chānd. Up.* IV, 1, 7.

¹² *nākaprṣṭha*. In India it is thought from the time of the *Rgveda* that the entire universe is round in shape. Therefore it probably points to the highest place of this round shape.

¹³ *saṃayapadānīti* / *saṃayasthānānīty etat* / *avaśyānuṣṭheyānīty arthaḥ* / (Śaṅkara).

Āp. Dh. S.	Kāthaka-Up
22, 4 <i>ahanyamāna</i>	<i>na hanyate hanyamāne śarīre</i> (II, 18) <i>nāyam hanti na hanyate</i> (II, 19). (cf. <i>Chānd. Up.</i> VIII, 10, 4: <i>Bhag. G.</i> II, 19, 20)
4 and 5, <i>guhāśya</i> (= <i>ātman</i>)	<i>eṣa sarveṣu bhūteṣu gūḍhātmā</i> (III, 12); <i>guhām praviṣṭa</i> (III, 1); <i>guhām praviṣya</i> (VI, 6; 7). (<i>eko devaḥ sarvabhūteṣu gūḍhaḥ</i> , <i>Śvet. Up.</i> VI, 11)
4, <i>te'mṛtāḥ</i> [<i>bhavati</i>]	<i>amṛtās te bhavanti</i> (VI, 9). <i>amṛtatvam ca gacchati</i> (VI, 8). <i>amṛto bhavati</i> (VI, 15). <i>amṛtatvam eti</i> (VI, 16).
5, <i>kavi</i> (= <i>krāntadarśin</i> , <i>medhāvin</i> , Śaṅkara) (and 23, 1)	<i>kavi</i> (= <i>medhāvin</i> , Śaṅkara) (III, 14)
6, <i>tejaskāya</i>	<i>tam eva bhāntam anubhāti sarvam tasya bhāsā sarvam idam vibhāti</i> (V, 15). cf. <i>Muṇḍ. Up.</i> II, 2, 10; <i>Śvet. Up.</i> VI, 14. (cf. the simile of sparks in the <i>Up.</i>)
6, <i>sarvatra nihitam</i>	<i>viddhi tvam etan nihitam guhāyām</i> (I, 14). <i>sarvabhūtāntarātman</i> (V, 10).
6, <i>mahāntam</i> . . . <i>sarvatra nihitam</i>	<i>mahāntam vibhum</i> (II, 20).
7, <i>nityo vipaścid</i> <i>amṛto dhruvaḥ</i>	<i>na jāyate mriyate vā vipaścin nāyam kutaś cin na babhūva kaścīt</i> / <i>aḥ nityaḥ śāśvato'yaṃ purāṇo</i> . . . (II, 18)
7, <i>anaṅgo'śabdo'śarīro</i> <i>'sparśaś ca</i> .	<i>aśabdam asparsam arūpam avyayam tathā'rasam</i> (III, 15).
7, <i>sa sarvam paramā</i> <i>kāṣṭhā</i> .	<i>kāṣṭhā sā parā gatiḥ</i> (III, 11). <i>paramā gati</i> (VI, 10).
8, <i>durdarśam nipuṇam</i>	<i>na hi suvijñeyam anur eṣa dharmah</i> (I, 21). <i>durdarśam gūḍham anupraviṣṭam guhāhitam</i> (II, 12). (According to Jacob's Concordance the word <i>durdarśa</i> is used only in the <i>Kāthaka-Up.</i>)
8, <i>modeta viṣṭape</i>	<i>modate svargaloke</i> (I, 12; 18).

- 23, 1, *nākaprṣṭhe*
virājati. *brahmaloke mahīyate* (III, 16).
 2, *aṇīyān bisornāyā*..
varṣīyāms ca *aṇor aṇīyān mahato mahīyān ātmā* (II,
prthivyāḥ... 20).

Some of the words, expressions, ideas and the like in the *Adhyātmapaṭala* are common to those in other *Upaniṣads*, but as is shown above, its accord with, or resembles to, the *Kāṭhaka-Up.* is overwhelming, and is conspicuous throughout nearly every *sūtra* of the *Adhyātmapaṭala*. Moreover, it is especially to be noted here that, according to the opening and ending *sūtras* of the *Adhyātmapaṭala*, it tries to teach the *yoga* concerning *ātman* (*ādhyātmikayoga*), and *Kāṭhaka-Up.* II, 12 teaches that one should realize the state of final release by means of the *yoga* concerning *ātman* (*adhyātmayoga*). According to Jacob's Concordance this technical term is used only in this place of the *Kāṭhaka-Up.* among the *Upaniṣads* which he dealt with. From the above facts we cannot but admit the existence of a remarkable resemblance between the *Adhyātmapaṭala* and the *Kāṭhaka-Up.* This may lead us to the following conclusion.

As already been discussed,¹⁴ the *Kāṭhaka-Up.* was composed during the period from 350 B.C. to 300 B.C. by (a) new poet thinker(s) who differed in the standpoint from the ancient Vedic theologians, and in the same current of thought were produced other *Upaniṣads* resembling remarkably the *Kāṭhaka-Up.* At present these have not been handed down, but a very limited portion of them has been transmitted as quotations in the *Adhyātmapaṭala* of the *Āpastamba-Dharmasūtra*. Since the composition of those *Upaniṣads* may have been around the same time as the *Kāṭhaka-Up.*, that of the *Adhyātmapaṭala* would be at the earliest 300-250 B.C. The date of the present edition of the *Āpastamba-Dharmasūtra* can neither be earlier than that, nor can be by far later than that.

So far it has generally been accepted on the basis of Georg Bühler's study that the *Āpastamba-Dharmasūtra* was composed in the 4th or 5th century B.C. The grounds for his arguments are as follows: Since the style and usage of words in the *Āpastamba-Dharmasūtra* show an archaic form which does not agree with the rules of Pāṇini's grammar, either the author did not know

¹⁴ Cf. H. Nakamura, *Shoki no Vedānta Tetsugaku* (in Japanese), Vol. I, pp. 25-37.

¹⁵ G. Bühler, *The Sacred Books of the East*, Vol. II, Introduction, pp. XL-XLIII. Cf. J. Jolly, *Recht und Sitte*, p. 3.

the Pāṇini's grammar (about 350 B.C.) or he did not think it important though he had known it. The archaic form of the book is not pseudo-archaic, since the irregularities in this book are peculiar to the *Āpastamba-Dharmasūtra* only and cannot be found in any other works. The *Āpastamba-Dharmasūtra* (I, 2, 5, 4 and following) calls the famous Śvetaketu "the man of his time" (*avara*) who appears in the *Satapatha-Bṛāhmaṇa* and the *Chāndogya-Up.* It might, therefore, have been written in a period not too remote from that of this Ancient *Upaniṣad*. Therefore, we may say that the same work belongs to the 5th or 4th century B.C.

However, those grounds alone are weak and flimsy. The fact that the text does not agree with the grammatical rules of Pāṇini does not make possible the inference that it was composed prior to Pāṇini. Although the *sūtra* works employed special usage, it is not at all surprising on account of their character. But, since it can be supposed that by the time of Patañjali (about 150 B.C.), Pāṇini's grammar was relied upon and used in general among scholars, it may be well to judge that this work came into existence prior to that date. Again there is no necessity to think that because Śvetaketu is called "the man of his time", the date of the *Āpastamba-Dharmasūtra* is close to that of the *Chāndogya-Up.* Pāṇini clearly states that there are two kinds of the *Bṛāhmaṇas*, old and new.¹⁶ Kātyāyana (about 250 B.C.) regards as "a man of his time" the famous Yājñavalkya who appears in both the *Bṛāhmaṇas* and the *Upaniṣads*, and calls him his "contemporary" (*tulyakāla*).¹⁷ For these reasons it is possible to think that there is several hundred years difference between the *Āpastamba-Dharmasūtra* and Śvetaketu, even though the former calls the latter "the man of his time". Therefore, it is by no means unreasonable to suppose that the *Dharmasūtra* took its present form in 300-250 B.C. (or even later than that).¹⁸ But, since there seems to be also a great number of old elements in this work which had been handed down and written before that time and were put together finally in this period, a further investigation is required.

¹⁶ Max Müller, *A History of Ancient Sanskrit Literature* (London, 1859), p. 361.

¹⁷ Max Müller, *ibid.*, p. 363.

¹⁸ According to Hopkins the *Āpastamba-Dharmasūtra* cannot have been in existence before the 2nd century B.C. As for the reason why it does not agree with Pāṇini's grammatical rules, it is explained as follows: The Pāṇini's grammar chiefly lays down the usage of the Sanskrit of north and in the Andhra of the South-East coast ancient linguistic characteristics had been preserved until later centuries (Rapson, *Cambridge History of India*, p. 249).

The *Adhyātmapaṭala* is systematically organized. In the first two *sūtras* it shows an outline of religious practice, next quotes passages from the *Upaniṣads* which explain *ātman* and finally lists the various virtues as the prescription of practice. As for the *Upaniṣadic* passages quoted in the *Adhyātmapaṭala*, they are not quoted at random but all of them are concerned with clarification of the nature of *ātman*. Even the *Kāṭhaka-Up.* which perhaps was composed in the same period as these passages and also has a close connection with them comprises not only such passages that explain abstractly the nature of *ātman* but also various extraneous arguments and many allegorical expressions whose meanings are not clear. This is a remarkable tendency especially in the ancient *Upaniṣads*. However, the *Adhyātmapaṭala* selects and quotes only those passages which explain clearly and straightforwardly what *ātman* is. Accordingly, from its method of quotation, we can infer the special attitude or standpoint of its editor. He selects the passages of the *Upaniṣads*. This attitude or standpoint can perhaps be said to be *Vedāntic*. The *Āpastamba-Dharmasūtra* does neither refer to the *Vedānta* school nor is the author himself probably conscious of the fact that such a standpoint is *Vedāntic*. But, we can find here the earliest germination of the *Vedānta*.

Further, since this *Adhyātmapaṭala* explains clearly the nature of *ātman*, it is regarded as important in the later *Vedānta* school to such extent that it is quoted in the commentaries of the *Brahmasūtra* by both Śaṅkara and Rāmānuja,¹⁹ and that, as we have already pointed out, there is a commentary ascribed to Śaṅkara.

As for the thought of the *Adhyātmapaṭala*, it is almost the same as that of the *Kāṭhaka-Up.* in the major points.

Ātman is the essence of all, including not only human beings but all varieties of living beings. It is maximum and, at the same time, minimum, hidden in the innermost place of all individual selves. Especially the fact that all living beings, that is to say, individual selves are called "castle" reminds us of Rāmānuja's philosophy, according to which all the spiritual beings and the material world constitute the "body" of the Absolute. Furthermore, *ātman* as the Absolute is said to be "good", "eternal", "constant", "great", "pure", "immortal", "wise", "spotless", "supreme", "root", "uninjured", "advantageous", "lord" and so on. These attributes are used in the other *Upaniṣads* as well and should not be regarded as peculiar to the *Adhyātmapaṭala*.

¹⁹ Śaṅkara *ad Brahmasūtra* II, 1, 1 (Vol. I, p. 421); *ad* I, 1, 17 (Vol. I, p. 121. *ātmalābhān naparam vidyate* = *Ap. Dh. S. I, 8, 22, 2*); Rāmānuja *ad Brahmasūtra* II, 1, 1 (p. 399).

With regard to religious practice, it teaches the *yoga* of meditating on and worshipping *ātman*. It calls the state of final release "peace" (*kṣema*). It clearly admits that final release is attained in the present existence. On the other hand, the expressions such as: "He . . . will rejoice in the heaven" and "The wise man . . . shines forth in the uppermost world of the heaven" indicate the idea that complete release is attained in reaching the heaven after death. The *Upaniṣadic* passages quoted in the *Adhyātmapaṭala* are chiefly concerned with the life of the wandering mendicant, but in the end of the chapter it prescribes that one ought to practice the *yoga* of meditating on *ātman* throughout all the four stages of life, i.e., the student, householder, forest-dweller and wandering mendicant. Therefore, the author of the *Āpastamba-Dharmasūtra* does not give any one-sided judgement on the problem taken up in later centuries: Should one who meditates on *ātman* become a wandering mendicant or is he permitted to lead a life of the householder? He must have thought that every member of the *Aryan* society should practice the above virtues.

By the way, why did the author of the *Āpastamba-Dharmasūtra* set up the *Adhyātmapaṭala* with such contents? The section is placed on the way of explaining the atonement for transgression in general, and the author intends to recommend the knowledge of *ātman* as the best means by which to purify the mind of those who have committed various sins.²⁰ It is, therefore, known that in the *Brahman* society of that time the knowledge of *ātman* was considered as capable of purifying the mind. It is to be noticed here that such a *Vedāntic* thought is mentioned here as the world-view of the author himself and not a mere different opinion. Even in this period the *Vedāntic* thought had already become a philosophy of the *Brahmans*.

It is only the *Āpastamba-Dharmasūtra* among the *Dharma-sūtras* in prose that sets forth the *Vedāntic* thought. As for the *Mīmāṃsā*, it is referred to in various *Dharmasūtras*. In *Vāsiṣṭhadharmasūtra* III, 20 and *Baudhāyanadharmasūtra*, I, 1, 8a "*Mīmāṃsaka*" is mentioned together with "one who knows the *Aṅgas*" and "one who recites the works on the sacred law".²¹ Calling the *Karmamīmāṃsā Nyāya*, the *Āpastamba-Dharmasūtra* not only follows the words of "the man who knows the *Nyāya*"²² but also lays down the same rules as those in the *Mīmāṃsāsūtra*.²³

²⁰ G. Bühler, *op. cit.*, p. XXIX.

²¹ *The Sacred Books of the East*, Vol. XIV, pp. 20; 144.

²² *Ap. Dh. S. II, 4, 8, 13; II, 6, 14, 13. Cf. G. Bühler, op. cit.*, pp. XXVII-XXVIII.

²³ According to Bühler, what is laid down in *Mīmāṃsāsūtra* I, 3, 3-4 is

It is, therefore, supposed that along with the *Vedāntic* tendency the *Karmamīmāṃsā* had already been established to some extent at that time.

After an investigation of various *Dharmasūtras* in prose we have to examine the *Mānavadharmasāstra*. It is said that simple metrical sentences like proverbs were originally collected and edited into the present form of the text in the 2nd or 3rd century A.D. In the first and the last (12th) chapter philosophical thought is explained but as scholars have pointed out it is *Vedānta* philosophy remarkably blended with the *Sāṃkhya* philosophy and influenced by *Mahābhārata* XII.²⁴ For these reasons it should be studied in connection with the *sāṃkhya* philosophy and the philosophy of the *Mahābhārata*. Therefore, I shall omit it here. But in the *Mānavadharmasāstra* there are some references to the study of the *Upaniṣads* and to its period and method. I shall examine them here since they give information about the transmission of the *Upaniṣads*.

"The *Brāhmaṇa* (vipra) who initiates a pupil and teaches him the *Veda* together with the *Kalpa* and the *Rahasyas*, is called "the teacher" [of the latter]." (II, 140)

"A twice-born must study the whole *Veda* together with the *Rahasyas*, performing various austerities (*tapas*) and the vows prescribed by the *Vedic* rules." (II, 165)

"He who studies the *R̥gvedasamhitā* three times with a concentrated mind or the *Yajurvedasamhitā* or the *Sāmavedasamhitā* together with the *Rahasyas* is freed from all sins." (XI, 262).

Since it can be thought that the "secret doctrine" (*rahasya*) mentioned here either refers to the *Upaniṣads* or at least includes the *Upaniṣads*, the compiler of the *Mānavadharmasāstra* is of opinion that the *Upaniṣads* are to be studied together with the *Samhitās*. Therefore, the *Upaniṣads* are regarded as subordinate to the *Vedas* and have not yet come to be evaluated more highly than the *Samhitās* as is the case with the later *Vedānta* scholars.

Thus the students studied the *Veda* (including the *Upaniṣads*) under the teachers. The Brahmins who taught them had families, wives and children.²⁵ Therefore, the teachers were not wandering mendicants. On the other hand, it is prescribed, those who

study the *Upaniṣads* do not directly realize their thought but after completing their duties as householders, they should renounce the world, meditate on *ātman* and focus their attention to the *Upaniṣads*. For example, the *Mānava-Dharmasāstra* prescribes that the *Brahman* who is a forest dweller, having undertaken various religious observances (*dīkṣā*), should study the *Upaniṣads* (*Aupaniṣadīr ātmasamsiddhaye śrutīḥ* [abhyaset, Comm.], VI, 29). Concerning the wandering mendicants, it says:

"One should always recite the sacred words [of the *Vedas*] with regard to the sacrifice, the sacred words related to the gods, and the sacred words concerning the *ātman* (*ādhyātmika*) taught in the *Vedānta* (*Vedāntābhihita*)." (VI, 83).

According to the *Mānavadharmasāstra*, it is possible only in the life of the wandering mendicant to seek final release through the *Upaniṣads* and it is strongly prohibited that the person who has not yet fulfilled his duties as a householder (the "three debts", i.e., the study of the *Veda*, the sacrifices for the gods and the bringing up of offsprings) has the desire to seek final release.

"After he has paid the three debts, let him turn his mind towards final release (*mokṣa*). But he who seeks it without having paid [his debts] sinks downwards (= goes to hell)." (VI, 35)

"Having studied the *Vedas* according to the rules and having begotten sons according to the sacred law, and having performed the sacrifices according to his ability, he then may turn his mind towards final release." (VI, 36)

"A twice-born man (*dviija*) who seeks final release (*mokṣa*) without having studied the *Veda*, without having begotten sons, and without having performed the sacrifices, sinks downwards." (VI, 37)

He can become neither a forest-dweller nor a wandering mendicant without passing through the stages of a student and householder. And these stages have to be passed through in successive order (cf. VI, 34). Therefore, although he studies the *Upaniṣads* when he is a boy or a youth, he realizes them after he becomes old and renounces the world. This may be comparable to the fact that in his old age a modern man can quietly appreciate and relish the classical works he studied when he was a boy or a youth.

Such a wandering mendicant had no definite place to live,

mentioned in *Āpastamba-Dharmasūtra* I, 1, 14, 8-10. (Bühler, *op. cit.*, pp. XXVIII-XXIX).

²⁴ G. Bühler, *Laws of Manu*, Introduction, pp. LXXIV, CXIV-CXVII.

²⁵ *Manu* III, 70; 78.

wandered about here and there and stayed in the shade of a tree²⁶ when he rested. Therefore, they had not yet known a group life in a great monastery. It may, therefore, be concluded that where the *Mānava-Dharmaśāstra* was current there had not yet come into existence anything like the later *Vedānta* school, which specially respected and studied only the *Upaniṣads* by settling in a monastery. Moreover, the custom of immediately renouncing the world without going through the life of a householder, which is seen in later centuries, was not socially admitted as yet.

The social significance of the *Vedāntic* thought which is known from the *Mānava-Dharmaśāstra* can also be recognized in other law books. For example, in the *Yājñavalkyasmṛti*, one of the most important law books of India, in which there is philosophical discussion, gives it incidentally, after it lays down the rules of the forest-dweller and wandering mendicant. According to the opinion of Losch, the portion of the philosophical discussion is a later addition to this law book,²⁷ but according to the opinion of its compiler the philosophical speculation on *ātman* is a matter of concern for the wandering mendicant. Therefore, in this point it is in accordance with the standpoint of the *Mānava-Dharmaśāstra*.

As for the philosophy of the *Yājñavalkyasmṛti*,²⁸ it is, in its contents, a *Vedānta* thought blended with the thought of the *Sāṅkhya* and *Yoga*. On this point as well it agrees with the *Mānavadharmasāstra*. A detailed examination of this matter will be made on another occasion. But the statement in the text (III, 110) that the *Āraṇyaka* *Yājñavalkya* obtained from the sun god, i.e. the *Brhadāraṇyaka-Up.*, should be known, is to be noted from the standpoint of the history of the early *Vedānta* philosophy. Furthermore, the text says that the *ātman*, like an immovable lamp, which abides in the center of the body should be realized, if he has realized it, he will not be born again in this world (III, 109). The view of *ātman* to be realized is typically a *pariṇāma-vāda*.

"Just as sparks fly out from a heated lump of iron, so do *ātman*s (i.e. individual selves) really come forth from the [single] *ātman*."

niḥsaranti yathā lohapinḍāt taptāt sphuliṅgakāḥ |
sakāśād ātmanas tadvad ātmānaḥ prabhavanti hi || (III, 67)

²⁶ Ibid., VI, 26.

²⁷ H. Losch, *Die Yājñavalkyasmṛti: Ein Beitrag zur Quellenkunde des indischen Rechts* (Leipzig, 1927), p. 75 f.

²⁸ M. Winternitz, *Geschichte der indischen Literatur*, Vol. III, p. 499.

This is a view of *ātman* which is widely seen in the *Vedānta* school in general as well as in the *Upaniṣads*. And it is exactly the view which the 3rd chapter of the *Māṇḍūkya-kārikā* and Śaṅkara denounce and reject.²⁹ This portion in the *Yājñavalkya-smṛti*, which was probably formed later than the 4th century,³⁰ reveals that such a view of *ātman* was current among authors of the *Dharmaśāstras* of that time.

A great number of works of law books in addition to those mentioned above have been written and handed down today, and the *Vedāntic* thought, which is frequently referred to in those texts, should be examined in the future. But the theory that one should practice both knowledge and action (*jñānakarma-samuccayavāda*) can be pointed out as one of the characteristics of the *Vedānta* thought which appears throughout the law books in general. This is the theory that religious practice should be combined with knowledge with which to contemplate *Brahman* in order to attain *Brahman*, the Absolute, one of them alone being insufficient to lead a man to final release. This is what Bhāskara emphasized later in sharp contrast with Śaṅkara's thought which attaches importance to knowledge (*jñāna*) only. But a tendency towards the former theory already appears in the law books.

"He who acts thus will become one with *Brahman*."
Baudhāyana-Dharmasūtra II, 7, 13, 13).³¹

"Just as [neither] horses devoid of carts nor carts without horses [can carry any load], so are both austerity (*tapas*) and knowledge [indispensable] to the ascetics." (*Hārītasṁṛti* VI, 10, 10).³²

"Just as the birds indeed fly with two wings, so does one attain the eternal *Brahman* by both knowledge and action (*jñānakarma*)."
(*ibid.*, VII, 10, 11).

The similes given here are also used in *Brahmasūtra* III, 4, 26.

Thus the law books agree, in their thought, with the later *Vedānta* philosophy to a considerable extent, but the influence of

²⁹ With regard to each of those passages, see my notes on *Māṇḍūkya-kārikā* III, 15 (H. Nakamura, *Shoki Vedānta Tetsugakushi* (History of Early Vedānta, Vol. III, 6) and H. Nakamura, *op. cit.*, Vol. II, 3, 5, pp. 24 ff.

³⁰ H. Losch, *op. cit.*, Einleitung, p. XIV-XVII.

³¹ *evam ācaran brahmbhūyāya kalpate /*

³² *yathāśvā rathahīnās ca rathās cāsvair vinā yathā /*
evam tapaś ca vidyā ca ubhāv api tapasvinaḥ / /
dvābhyām eva hi pakṣābhyām yathā vai pakṣinām gatiḥ /
tathaiiva jñānakarmabhyām prāpyate brahma śāśvatam / /
(Belvalkar, *op. cit.*, pp. 168-169)

the law books upon the *Vedānta* is by far greater in respect of the rules of practice and life. The way of the ascetics' practice and life is discussed in *Brahmasūtra* III, 4, where the three commentators, Śaṅkara, Bhāskara and Rāmānuja, refer as its scriptural testimony to the *Gautama-Dharmasūtra*, the *Āpastamba-Dharmasūtra*, the *Dakṣasṃṛti*, the *Atrismṛti* and the *Mānava-Dharmaśāstra*.³³ Therefore, the law books seem to have exercised a great influence upon the rules of practice and life.

II

The Definition of Science in the Arthaśāstra and the Upaniṣadic Study

Alongside of the law books we must take up the *Arthśāstras* for discussion. The Indian people of the ancient period thought that the three objects (*trivarga*) to be sought for by mankind are *dharma* (virtue), *artha* (wealth) and *kāma* (love). The *Dharmaśāstras* command the realization of order in human society whereas the *Arthaśāstras* teach how to obtain wealth most efficiently. The most important and representative example of the *Arthaśāstras* is the *Kauṭīliya-Arthaśāstra* traditionally ascribed to Kauṭīliya (or, Cāṇakya), who was the prime minister of Candragupta, the founder of the Maurya Dynasty. It is a guide book for the statesmen concerning politics, economics, diplomacy, conduct of life and so forth. It is valuable for getting information about the actual conditions of the ancient Indian society. All of the contents, however, are not from the pen of Kauṭīliya himself, but it is supposed that it assumed its present form perhaps in the 3rd century A.D.¹

Since this work teaches chiefly the artifice and machination of politics without regard for the means used to obtain the objective, it has frequently been compared to the *Il Principe* by Machiavelli, and its central thought is very utilitarian, realistic and materialistic. It seems that the author was deeply versed in the thinking way of the *Vaiśeṣika* philosophy.² Therefore, its contents have almost no connection with the *Vedānta* philosophy. Let us, however, examine the text since there are very significant references to the social evaluation of the *Upaniṣadic* study.

The *Kauṭīliya-Arthaśāstra* recognizes the four sciences (*vidyā*)

in the first chapter (*vidyāsamuddeśa*).³ They are (1) philosophy (*ānvīkṣikī*), (2) theology (*Vedic* study, *trayī*), (3) economics (*vārttā*), and (4) judicature (*daṇḍanīti*). Among these sciences (1) philosophy comprises the *Sāmkhya*, *Yoga*, and *Lokāyata* (*Sāmkhyam Yogo Lokāyatam cety ānvīkṣikī*). What is full of interest here is that it makes no reference to the two schools of *Vaiśeṣika* and *Nyāya*. The later *Nyāya* school asserts that philosophy (*ānvīkṣikī*) is nothing but the *Nyāya* itself. Nevertheless these two schools are not referred to in it. This may point to the fact that they may not have yet been fully recognized as a philosophic school of that time. Furthermore, neither the *Mīmāṃsā* nor the *Vedānta* school are referred to. What is the reason for that? It is an indubitable fact that in about 3rd century A.D. when the *Kauṭīliya-Arthaśāstra* was compiled into its present form, these two schools were already in existence, but the fact that here they are not referred to indicates perhaps that the author of the *Arthaśāstra* did not recognize both schools as schools of philosophy. According to the *Kauṭīliya-Arthaśāstra*, the essence of philosophy is the demonstration and investigation through reasoning (*hetubhir anvīkṣamānā . . .*).⁴ But it is difficult to admit that the *Mīmāṃsā* and the *Vedānta* are schools which carry on purely theoretical and philosophical speculation. Both schools regard the *Veda* as absolute and carry out philosophical speculation only in relation to them. Therefore, the *Arthaśāstra* treats the two schools as belonging to the *Vedic* study (*trayī*).

If we are more faithful to the historical fact, it is a new attitude that the author of the *Arthaśāstra* made philosophy an independent science. Some other scholars do not accept independence of philosophy itself but regard it as a special field of theology (*trayī vārttā daṇḍanītiś ceti Mānavah / trayīviśeṣo hy ānvīkṣikīti /*).⁵ In opposition to such a view the author of the *Arthaśāstra* gives the three sciences, *Sāmkhya*, *Yoga* and *Lokāyata*, an independent academic status as philosophy, thinking that the three sciences should be distinguished from theology. One is already seen in the old law books to contrast philosophy with theology. For example, the *Gautama-Dharmasūtra* (XI, 3) says, "[The king] should be fully instructed in the threefold *Veda* and in philosophy"⁶ (*trayyām*

³ Jacobi has already examined this place ('Zur Frühgeschichte der indischen Philosophie', *Sitzungsberichte der Preussischen Akademie der Wissenschaften in Berlin*, 1911, p. 732 ff.

⁴ J. Jolly, *op. cit.*, p. 4.

⁵ J. Jolly, *op. cit.*, p. 4.

⁶ I have followed Jacobi, *op. cit.*

³³ Cf. H. Nakamura, *op. cit.*, Vol. II, 4, pp. 75 ff.

¹ M. Winternitz, *Geschichte der indischen Literatur*, Vol. III, p. 523.

² J. Jolly, *Arthaśāstra of Kauṭīliya* (Lahore, 1923), Introduction, p. 25.

ānvīkṣikyām cābhivinitaḥ). Accordingly, the tendency to regard philosophy as an independent science had already existed from ancient time, but it is probably the *Kauṭīliya-Arthaśāstra* that particularly emphasized this point. In view of such facts it would seem reasonable that the *Mīmāṃsā* and the *Vedānta* school which had a close relationship with the *Veda* were included in theology (*Vedic study*).

Therefore, even in this period one group of the *Brahmans* who followed the *Upaniṣads* continued to exist but the author of the *Arthaśāstra* looked upon them as a group of Vedic theologians rather than philosophers who carried on logical speculation since they were still scholars of exegesis from the viewpoint of the author of *Arthaśāstra*. It is, therefore, not at all surprising that neither *Mīmāṃsā* nor *Vedānta* is mentioned.

The same evaluation is seen in the case of the *Arthaśāstra* scholar, Kāmandaki (6th century).⁷ He also thought the sciences of the *Mīmāṃsā* and *Vedānta* could be included in the *Vedic study* (*trayī*).⁸ Again the opinion which sets up only fourfold science, i.e., philosophy, theology, economics and judicature was accepted by the *Yājñyavalkyasmṛti*⁹ (I, 310) and the scholars of the *Nyāya* school. Further, as we shall mention later,¹⁰ such an evaluation of the *Vedānta* school was also inherited by the *Nyāya* school. Therefore, the method of classifying sciences in the *Kauṭīliya-Arthaśāstra* had long been a model and restricted later scholars, by whom the *Upaniṣadic study* was not accepted as an independent philosophy.¹¹

By the way, the fact that the author of the *Arthaśāstra* neglected the *Vedāntic study*, thinking it to be a kind of *Vedic theology*, reveals that the *Vedānta* philosophy was outside his interest. His main concern was with the means by which to strengthen his country and to increase power. It is natural that the kings, politicians, or the worldly *Brahmans* as their advisors, who were in such mentality that they stick at nothing to gain their ends, employing every possible form of tactics, kept them-

selves far from the *Vedānta* philosophy.

The *Kāmasāstras* are also completely the same in the point that they neglect the *Vedāntic thought*. It has frequently been pointed out that the *Kāmasūtra* (4th century A.D.), the oldest extant text of this kind, is similar to the *Kauṭīliya-Arthaśāstra* in its construction and way of expression. Its author affirms that in order to enjoy sexual pleasure one may violate the moral codes and perform such illegal action as can be regarded as crime. He asserts that the science of *kāma* can be established as those of *dharma*, *artha* and *mokṣa* can be. Therefore, it cannot be imagined that he totally denies the *Vedānta* which teaches *mokṣa*. However, his concern was perhaps completely disconnected from the mentality of the *Vedāntic* seekers. Since he taught for the city-dwellers (*nāgaraka*), the debauchees who indulge in enjoyment in cities were widely separated from the *Vedānta* philosophy.

From the above facts we could come to the following conclusion: until the period of the 3rd or 4th century A.D., the kings and wealthy merchants of large cities were absorbed in aggressive warfare in order to increase their power over other countries or were busy acquiring huge amount of wealth and property or spent every night in the sexual enjoyment and pleasure of sumptuous feast. These rulers and influential people of cities did not pay so much attention to the *Vedānta* philosophy. Therefore the *Upaniṣads* were handed down and studied in a different social footing.

⁷ According to the study undertaken by Formichi from the astronomical point of view Kāmandaki died at the same time as Varāhamihira, who died in A.D. 587, or a little before that. Jacobi has confirmed the theory of Formichi with the consideration of other data (cf. Jacobi, *op. cit.*). However, Winternitz, *op. cit.*, p. 526 assigns him to the date A.D. 700-750.

⁸ *āṅgāni Vedās catvāro Mīmāṃsā Nyāyavistarāḥ / dharmaśāstram Purāṇam ca Trayīdam sarvam ucyate //*
Cf. *upāṅgadvyayam caitan Mīmāṃsā Nyāyavistarāḥ*,

Ahīrbudhnyasamhitā XII, 12.

⁹ But *Manu VII, 43* distinguishes *trayī vidyā* from *ātma vidyā*.

¹⁰ Cf. H. Nakamura, *op. cit.*, Vol. I, pp. 485 ff.

¹¹ Winternitz, *op. cit.*, p. 540.

“Numberless” in the Mahābhārata

I

The literature of each highly developed civilization possesses a rich stock of poetic and symbolic phrases. The poetic phraseology and some poetic conventions, invented by each such civilization, and consequently more or less imbued with distinctive cultural features, lead us back to the mythology of antiquity and cause us to reflect on the peculiarity of that individual culture. Sanskrit literature, which developed through the ages a number of figures of speech, is no exception to this rule. Similes and metaphors appeared as early as in the oldest text, the *R̥gveda*,¹ and fully developed by the age of the Gupta empire, and finally were elaborately refined by such skilled poets as Bhāravi, Māgha, Bāṇa, Subandhu, and Śrīharṣa.² These poetic techniques were studied and classified systematically by many critics of poetry, who established rules for poetical conventions (*samaya*).³ Poets and

those critics of poetry exerted a mutual influence on each other and seem to have contributed to the refinement of the Sanskrit poetical phraseology.

Numbers in Sanskrit literature were also influenced by a kind of poetical convention. But in the case of numbers an ancient magical belief was also present. In ancient India, number was originally considered to be an attribute of substance,⁴ and substance and attributes inherent in substance were believed magically to constitute unity.⁵ Influenced by the belief in the magical essence of numbers, ancient Indians supposed some numbers to connote certain objects and to be substitutes for the objects themselves. A typical example is the number six, which is the number of seasons and consequently was regarded to represent the seasons themselves. Similarly, the number three represented the steps of the god Viṣṇu, the number five represented the elements (*bhūta*) and the number seven represented the ancient sages.⁶ These numbers were more or less fixed, and understood to be peculiar to particular objects. For this reason in astronomy, mathematics and metrics manuals as well as in inscription and manuscript dates numbers were expressed by names of things, beings or ideas, which connoted numbers.⁷ Because these numbers were commonly understood in the society of educated people, numbers were used in sophisticated conundrums in ancient India.⁸ Moreover, the idea of holy numbers

dravya-kriyā-samaya; and chapter 15, with *guṇa-samaya* (whiteness for laughter and fame, blackness for ill-fame and evil deeds, redness for anger, etc.).

⁴ Cf. the *Vaiśeṣika Sūtra* 1. 1. 6.

⁵ Cf. B. Heimann, “Die Dingbeziehungen in den alten Upaniṣaden,” *Zeitschrift für Indologie und Iranistik* 6 (1928), p. 85.

⁶ For a classified list of numeral symbolisms, cf. G. Bühler, *Indische Palaeographie* (Strassburg, 1896), pp. 80-83 and P. V. Kane, *History of Dharmaśāstra*, vol. 5, pp. 701-703. Cf. also *Mahābhārata* 3.134.7-19 and *Sūrya-śataka* 13.

⁷ Cf. G. Bühler, *op. cit.*, p. 80.

⁸ For example, *Rig Veda* 4. 58. 3, which is originally sung for the *Soma*, is interpreted in various ways.

catvāri śṛṅgā trāyo 'sya pāda dvē śirṣe sapta-hāstāso asya (ab) Patañjali interprets the four horns as four parts of speech, three feet as three tenses, two heads as nominal and verbal endings, and seven hands as seven cases. Besides those sacrificial and grammatical interpretations another interpretation is introduced by Sāyaṇa *ad loc.* For this stanza, see also, B. Liebich, “Über den Sphoṭa,” *Zeitschrift der Deutschen Morgenlandischen Gesellschaft* 1923, p. 213.

P. C. Chakravarti, *Philosophy of Sanskrit Grammar* (Calcutta, 1930), pp. 19-20.

¹ Cf. A. Hirzel, *Gleichnisse und Metaphern im R̥gveda* (Leipzig, 1890). A. Bergaigne, “Quelques observations sur les figures de rhétorique dans le Rig-Veda,” *Mémoire de la société linguistique de Paris* 4, pp. 96 ff.

A. Weller, “Zu einigen Metaphern des Rigveda,” *Zeitschrift für Indologie und Iranistik* 5 (1927), pp. 178-184.

“Vergleichungen im Rigveda,” *Festschrift R. Garbe* (Leipzig, 1927), pp. 54 ff.

A. Venkatasubbiah, “Some Similes in the Rig-Veda,” *The Adyar Library Bulletin* 28 (1964), pp. 161-207.

² Cf. H. von Glasenapp, “Das Gleichnis in der Vedānta-Philosophie,” *Festschrift W. Kirfel* (Bonn, 1955), pp. 87-100 and notes 1 and 2 (cum lit.).

K. C. Pillai, *Similes of Kālidāsa* (Calcutta, 1945).

M. D. Paradkar, *Similes in Manusmṛti* (Delhi, Patna, Varanasi, 1960)

M. Hara, “Moon-similes in Bhāsa's Plays,” *Festschrift R. Yuki* (Tokyo, 1964), pp. 109-133.

³ For example, the *Kāvya-mīmāṃsā*, chapter 14 deals with *jāti-*

was expressed in Sanskrit literature,⁹ and there were also certain exaggerated great numbers (88.000, etc.), which ancient India seems to have shared with ancient China.

Those number symbols¹⁰ should be studied philologically and arranged chronologically, but an exhaustive investigation would require us to spend a vast amount of time and energy. Here, in this paper, we shall limit ourselves to collecting the expressions for "numberless" which are scattered in the great Epic, *Mahābhārata*.¹¹ After arranging those expressions systematically and examining them carefully, we hope to discern the particular objects about which ancient Indians held the idea of numberlessness. A future comparative study of expressions of this kind which are found in the literature of various cultures may also enable us to discover ways of thinking peculiar to these cultures.

⁹ Cf. S. Rodhe, *Deliver us from Evil, Studies on the Vedic Ideas of Salvation* (Lund-Copenhagen, 1946), p. 15, note 88 (cum lit.).

J. Gonda, *Change and Continuity in Indian Religion*, p. 124, note 46.

¹⁰ For the numbers one and two, cf. J. Gonda, *Reflections on the Numerals "One" and "Two" in Ancient Indo-European Languages* (Utrecht, 1953). For the number three, cf. G. Dumézil, *L'idéologie tripartite des Indo-européens* (Bruxelles, 1958) and J. Brough, "The Tripartite Ideology of the Indo-europeans: An Experiment in Method," *Bulletin of the School of Oriental and African Studies*, University of London 22, 1959, pp. 68-85.

As for the significance of particular numbers, I list below at random the studies carried out by modern scholars with respect to the follows numbers :

7 : J. Gonda, *Aspects of Early Viṣṇuism* (Utrecht, 1954), p. 59, note 28 (cum lit.).

8 : R. B. Pandey, *Hindu Samskāras* (Benares, 1949), p. 257.

9 and 10 : J. C. Heesterman, *The Ancient Indian Royal Consecration* (The Hague, 1957), pp. 176-177.

12 : Heesterman, *op. cit.*, p. 176 and E. W. Hopkins, *The Great Epic of India* (New Haven, 1920), p. 371.

16 : Heesterman, *op. cit.*, p. 13 and J. Gonda, *Change and Continuity in Indian Religion* (The Hague, 1965), pp. 115-130 (cum lit.).

17 : Heesterman, *op. cit.*, p. 135 and J. Gonda, *Ancient Indian Kingship from the Religious Point of View* (Leiden, 1966), p. 84.

18 : Hopkins, *op. cit.*, p. 371.

21 : Heesterman, *op. cit.*, p. 99.

For the numbers 5 and 12, cf. also J. F. Kohl, "Einige Bemerkungen zur Zahlensymbolik und zum Animismus in botanischen System des Jaina-kanon," *Festschrift W. Kirfel*, pp. 125-135.

¹¹ References to the *Mahābhārata* are based upon the Poona Critical Edition.

II

In the *śravaṇa-phala* of the *Śiva-stuti-māhātmya*, we read as follows :

*yāvanty asya śarīreṣu roma-kūpāni bhārata
tāvad varṣa-sahasrāṇi svarge vasati mānavaḥ* (13.18.59)

"A man (who recites this) resides in heaven for as many thousand years as there are pores on his body (*śarīra*)."

The innumerable character of pores is repeated in a similar context, where the merit of giving is praised as follows :

*yāvanti roma-kūpāni tasya gātreṣu pāṇḍava
tāvanty eva sahasrāṇi varṣāṇām divi modate* (13.109.61)

"Such a person enjoys (all kinds of happiness) in heaven for as many thousand years as there are pores on his body (*gātra*)."¹²

Besides the pores on the human body, the hairs of a cow are considered to be innumerable. In praise of the merit of giving a cow, it is said :

*dhenum dattvā suvratām sādhu-dohām kalyāṇa-vatsām
apalāyinīm ca
yāvanti romāni bhavanti tasyās tāvad varṣāṇy āsnute
svarga-lokam* (3.184.9)

"By giving a cow that is of good disposition, that yields herself properly to be milked, that brings forth good calves, and that does not flee away (from the owner's abode), the giver enjoys felicity in heaven for as many years as there are hairs on her body."¹³

¹² Cf. *Kūrma Purāṇa* (the Venkatesvara Edition) 1.36.48 and 1.38.4 ;
*tasya yāvanti lomāni santi gātreṣu sattama
tāvad varṣa-sahasrāṇi rudra-loke mahīyate* (1.36.48)
*yāvanti roma-kūpāni tasya gātreṣu bhūmīṣu
tāvad varṣa-sahasrāṇi svarga-loke mahīyate* (1.38.4)

¹³ Cf. the following Epic passages with slight variations :
*dattvā dhenum suvratām kāmasya-dohām kalyāṇa-vatsām
apalāyinīm ca
yāvanti lomāni bhavanti tasyās tāvad varṣāṇy āsnute
svarga-lokam* (13.70.32)
*dattvā dhenum suvratām sādhu-vatsām kalyāṇa-vṛttām
apalāyinīm ca
yāvanti lomāni bhavanti, tasyās tāvanti varṣāni vasaty
amutra* (13.72.42)

The same merit is described again in a similar context :

*yāvanti lomāni bhavanti dhenvās tāvat phalam prāpnute
go-pradātā
putrāṁś ca pautrāṁś ca kulam ca carvam ā saplamam
tārayate paratra (13.59.29)*

“Such a person, who gives a cow, enjoys as many fruits (of his good conduct) as there are hairs (on the body) of the cow, and rescues in the next world (from the misery of hell) his sons, grandsons, and all his race up to the seventh degree.”¹⁴

In the next verse, the first quarter of the previous verse is repeated, and the remainder promises to the giver of a cow a different kind of reward :

*yāvanti lomāni bhavanti dhenvās tāvanti varṣāṇi
mahīyate saḥ
svargāc cyutaś cāpi tato nṛ-loke kule samutpatsyati
gominām saḥ (13.78.27)*

“The man who makes a gift of a cow is honoured (in the next world) for as many years as there are hairs (on the body) of the cow. Falling off from heaven (upon the exhaustion of his merit) such a man will be born in a family of men, rich in herds.”

It is also believed that imperishable worlds of felicity exist in each and every hair of a cow. Though the meaning of the verse is somewhat obscure, a verse which praises the merit of giving a cow to a Brahmin reads as follows :

*yaś cātma-vikrayam kṛtvā gāḥ kṛtvā samprayacchati
yāvatīḥ sparśayed gā vai tāvat tu phalam āsnute
lomni lomni mahābhāga lokāś cāsyākṣayāḥ smṛtāḥ
(13.72.33)*

¹⁴ Usually the expression of “up to the twenty-first degree” appears rather than “the seventh degree (cf. *Vāyu Purāṇa* 105. 11).” Cf. *triḥ-sapta-kulam* : *Vāyu Purāṇa* 105.44, 106.86, 112.58, *Liṅga Purāṇa* 107.42, 112.26, *Saura Purāṇa* 65.82. *eka-vimśati-kulāni* : *Vāyu Purāṇa* 112.27, cf. *Kūrma Purāṇa* 2.41.77 *kulaikavimśatim* : *Agni Purāṇa* 375.5, *Saura Purāṇa* 69.20 *trisapta-puruṣānvitāḥ* : *Saura Purāṇa* 46.51 Cf. also *Mahābhārata* 1.86.7, 12.235.23, 13.61.34, 13.83.27. In connection with *Paraśurāma (triḥ-sapta-kṛtvāḥ)*, cf. *Mahābhārata* 1.58.4, 1.98.3, 3.117.9, 8.22.39, 12.48.9-10, 13.14.138, 13.83.30, 14.29.18 and *Brahmāṇḍa Purāṇa* 3.46.36.

“That man who sells himself¹⁵ and with the proceeds thereof purchases cattle and gives them (to a Brahmin) enjoys as much felicity (*phala*) (in the next world) as there are (the hairs on the body of) the cattle he would touch. It is traditionally said that there exist inexhaustible regions (of felicity) in each and every hair of those cattle, O thou of great fortune !”

The innumerable character of a cow’s hairs is also referred to in quite an opposite context :

*ghātakah khādako vāpi tathā yaś cānumanyate
yāvanti tasyā lomāni tāvad varṣāṇi majjati (13.73.4)*

“All these, viz., he that kills, he that eats, and he that permits the slaughter of a cow, rots in hell for as many years as there are hairs on the body of the cow (so slain).”¹⁶

The hairs of a horse appear in place of those of a cow where the giving of a horse is praised :

*yāvanti romāṇi haye bhavanti hi nareśvara
tāvato vāji-dā lokān prāpnuvanti mahīpate (5.112.19)*
“Those who give a horse attain as many worlds (of felicity) as there are hairs (on the body of) the horse.”

Beside hairs of cows and horses, those of bear seem to be noted for innumerability. In praise of the merit of fasting for five days, it is said :

*ayutāni ca pañcāśad ṛkṣad-carma-śatasya ca
lomnām pramāṇena samam brahma-loke mahīyate
(13.110.28)*

“He is honoured in the region of Brahman for fifty million years, the number being equal to the number of the hairs found upon the skin of one hundred bears.”¹⁷

¹⁵ Usually, and especially in the Purāṇic literature, *-vikraya* contains a sinful connotation as is seen in the case of *soma-vikraya* or *veda-vikraya* (cf. *Kūrma Purāṇa* 2.21.29). But here it is used in a “good” sense.

¹⁶ For this “remaining in hell,” compare the following passages, *apahrtya tu yo gām vai brāhmaṇāya prayacchati yāvad dāne phalam tasyās tāvan nirayam ṛcchati (13.73.6)* *āmantritas tu yaḥ śrāddhe daive vā māmsam utsṛjet yāvanti paśu-romāṇi tāvato narakān vrajet (Kūrma Purāṇa 2.17.40)*

¹⁷ An expression of hairs of animal with no specification of the particular animal is found in the *Kūrma Purāṇa* 2.17.40 (*paśu-roma*).

Beside pores and hairs, human bones are mentioned in a somewhat similar context. In praise of the merit of bathing in the River Ganges it is said :

*yāvad asthi manuṣyasya gaṅgā-toyeṣu tiṣṭhati
tāvad varṣa-sahasrāṇi svargaṁ prāpya mahīyate* (13.27.31)
“He (who bathes in the water of the Ganges) is honoured after he has attained heaven for as many thousand years as his bones remain in the water of the Ganges.”¹⁸

Although here the passage is somewhat similar to those which we have discussed above this verse speaks of the imperishability, rather than the innumerability, of bones which are scattered into the sacred river after cremation.

III

Apart from those parts of living beings, such as pores, hairs, and bones, numberlessness is also attributed to natural objects. Among these natural objects sand comes first, as in the Old Testament.¹⁹ In an account of the abundant gifts of the king Gaya, we read as follows :

*yāvatyaḥ sikatā rājan gaṅgāyāḥ puruṣarṣabha
tāvatir eva gāḥ prādād āmūrtarayasō gayāḥ* (12.29.111)
“The king Gaya, son of Amūrtarayas, gave (to Brahmins) as many cows as there are sands (on the banks) of the River Ganges.”

Beside sand, stars and rain drops are referred to as being innumerable. In praise of the same generous king, it is said :

*sikatā vā yathā loke yathā vā divi tārakāḥ
yathā vā varṣato dhārā asamkhyeyās ca kenā cit* (3.121.8)
“(The king Gaga gave abundant gifts to Brahmins) enumerable by no one, as sands on the earth, stars in heaven, and lines of rain (in between).”

¹⁸ Cf. *Kūrma Purāṇa* 1.37.32

*yāvad asthīni gaṅgāyām tiṣṭhanti puruṣasya tu
tāvad varṣa-sahasrāṇi svarga-loke mahīyate*

¹⁹ Cf. *The Old Testament*, Genesis 22 : 17 and Hosea 1 : 10. I owe these references to Mrs. Russell Munk. Sands are also familiar in Japanese proverbs.

Rain drops, perhaps more than sand and stars, are especially noted for innumerability. While promising a reward to a poor man for fasting equal to the reward given to a rich for a pompous sacrifice, Bhīṣma said to Yudhiṣṭhira :

*yāvad varṣa-sahasram tu jambū-dvīpe pravarṣati
tāvat samvatsarāḥ proktā brahma-lokasya dhīmataḥ* (128)
*vipruṣās caiva yāvantyo nipatanti nabhas-talāt
varṣāsu varṣatas tāvan nivasaty amara-prabhāḥ* (13.110.129)

“Endowed with great wisdom he resides in the region of Brahman for as many years as are measured by the drops of rain that fall in the course of a thousand years on the division of the Earth which is called Jambūdīpa. Possessed of the effulgence of a deity he lives there for as many years as the drops of rain that fall from the sky in the season of showers.”

In addition to sand and rain drops, the great River Ganges seems to have been known for her innumerable under-currents. In a dialogue between the God Brahman and the king Bhagīratha, who attained the world of Brahman, we read as follows :

*srotaś ca yāvad gaṅgāyās channam āsij jagat-pate
dakṣiṇābhiḥ pravṛttābhir mama nāgām ca tat-kṛte*
(13.106.24)

“(In those sacrifices), O Lord of the Universe, the presents that flowed from me were as copious as the hidden streams of the Ganges herself. But it is not on this account that I attained (this region of yours).”

Stones found in the great mountain, Meru, and drops of water in the ocean are also impossible to count. In emphasising the innumerability of merits which are attributed to the sacred river Ganges, it is said :

*meroḥ samudrasya ca sarva-ratnaiḥ samkhyopālānām
udakasya vāpi
vaktum śakyam neha gaṅgā-jalānām guṇākhyānam
parimāṭum tathāiva* (12.27.97)

“One might, putting forth one’s whole wealth, count the stones that occur in the mountain, Meru, or measure the waters that occur in the ocean, but it is impossible for him

to count the merits (*guṇa*) attributed to the water of the Ganges."

Twinklings of eyes are innumerable, too. Though the meaning is not entirely clear, a verse which praises the merit of giving a lamp to a Brahmin reads as follows :

*yāvad akṣi-nimeṣāni jvalate tāvatih samāḥ
rūpavān dhanavāms cāpi naro bhavati dīpa-daḥ* (13.103.37)

"The man who gives a lamp becomes endowed with beauty and wealth for as many years as correspond to the number of twinkles (viz., instants) for which the lamp given by him will blaze."

IV

From the above investigation the following points become clear : The objects which the ancient Indians considered to be innumerable are not too many in number, but are various in nature. However, we can classify them into two categories. Those belonging to the first category concern parts of bodies of living beings. Among these are human pores, hairs of animals, and human bones, although imperishability of bones, rather than their innumerability seems to be implied. Those belonging to the second category are objects of the natural world. Among them are sands on the banks of the River Ganges, drops of water in the ocean, stones in the great mountain, and hidden streams of water in the great river. All these exist on the earth. In heaven, stars are considered to be innumerable. Further, between heaven and earth rain drops and lines of rain are said to be numberless.

But, if we look at those passages in which innumerable things are mentioned from a different angle, we further discern some deeper socio-religious significance. First, the passages in which the innumerable objects are described are more or less those which speak of the merit of good deeds and the punishment of evil conduct. Promises of reward and warning of punishment have a bearing on the future world in one way or the other, which surpasses the imagination of human beings in this world. Endlessness, or innumerability, seems to belong to the next world, rather than to this world. Second, we do not miss the totemistic implications of those passages which promise rewards attendant to giving particular animals to Brahmins. Those who give a cow will enjoy felicity in heaven for as many years as the number of the cow's hairs, and those who injure a cow will suffer punish-

ment in hell for the same number of years.²⁰ The description of the merits of giving a horse is only a variation of the description of the merits of giving a cow, substituting a horse's hairs in place of cow's hairs. This correspondence between the giving of a cow and the cow's hairs seems to extend to the giving of a lamp and twinkles. Lamps, or more precisely light, and eyes are related to each other, and their relationship is fully discussed in ancient Indian epistemology. This correspondence between light and eyes is proved not merely by ordinary optical experience, but also by the etymological derivation of the Sanskrit word for eyes (*cakṣus*, *ca-kṣ-us*) from the verbal root for light or shine (*kāś-*). But above all, throughout those passages a religious atmosphere predominates. There are enumerated merits, that belong to the sacred River Ganges, that result from hearing the greatness of the God Śiva, or that come from religious donation of a sacred animal, a cow, to a Brahmin.

In concluding this paper the writer prays that Professor Kosambi will enjoy felicity in heaven. Not necessarily as a result of merit obtained by giving a cow, but because of the merit of his learning, may the great scholar, Professor Kosambi, be honoured in heaven for many thousand years!!*

²⁰ One is reminded of the famous folk etymology of the Sanskrit word for meat (*māmsa*).

*mām sa bhakṣayitāmutra yasya ihādmy aham
etan māmsasya māmsatvam pravādanti manīṣiṇaḥ*

(*Manusmṛti* 5.55)

"Me he (*mām saḥ*)" will devour in the next world, whose flesh I eat in this life ; the wise declare this (to be) the real meaning of the word "flesh (*me-eat*)."

Cf. also the *Mahābhārata* 13.117.34.

* I would like to express my deepest thanks to Mr. Russell L. Munk for kindly reading and offering certain suggestions with respect to the English of my original manuscript.

Aspected Logical Reason in Asaṅga's Madhyāntānugama-śāstra

Interpreting what is said as the three aspected logical reason in Asaṅga's Madhyāntānugama-śāstra, Prof. H. Ui divided the text concerned into the four parts, each part indicating 1. pakṣa dharmatva, 2. vipakṣe nāstitā, 3. sapakṣe sattva, 4. an example of the demonstration which is basing on the three aspected logical reason.¹

There is a problem, according to Prof. Ui, on the part indicating 3, since this part can be understood as "isvapakṣa is established too".

Prof. Hadano has shown his interpretation in three ways, in one of which, taking the parts indicated as 2 and 3 as avīta, he concludes that what are said there is the explanation on vīta and avīta.²

Agreeing with Prof. Hadano's view, the author of the present article takes the part indicated as 1 for vīta, the part as 4 for vākya which is expressing vīta-hetu.

The part indicated as 1 is exactly expressing pakṣadharmatva.

Vīta-hetu is parallel to pakṣadharmatva³ and later on clearly

I am deeply indebted to Prof. V. V. Gokhale for his guidance in studying the Tibetan Tarkajvālā, Chap. 6, in the light of Sanskrit text of the Madhyamakahrdaya. He has also kindly improved my English.

I am deeply indebted to Prof. H. Nakamura too for his important suggestions and advice in preparing this article.

¹ H. Ui: Studies in Indian Philosophy, Vol. V, (Tokyo, 1929), pp. 429, 452. See Taisho-daizokyo, Vol. 30, p. 42, (No. 1565), "Shuen-chung-lun".

² H. Hadano: Suron gakuha no ronri setsu, vīta avīta ni tsuite, Bunka, Vol. XI, No. 3, pp. 177-219, No. 4, pp. 300-326, (Sendai, 1944). Studies on Vīta and Avīta in Japanese, *ibid.*, p. 314—especially. He mentions parallel passages from PSV. (Snar-than, B, 144, b, A, 61b-62a, Sde-dge, 56a), NV. p. 123, 1.6; 11.8 f.

³ Svarūpa is used to define vīta-hetu and this is considered to be the point of vīta-hetu's being parallel to pakṣadharmatva. (a) Svarūpa as Sādhāraṇa is commented as "yathāvad āśrīyamāṇo'rthātmā" (the charac-

teristic of the thing kept in mind properly), Yd. p. 40, 1.26; (b) Svarūpa as asādhāraṇa is said to be of such reason as parimāṇa, anvaya and saṃghātaparārthatva etc. (the last of which is not pakṣadharmatva but is capable of being examined from the point of view of sapakṣe sattva; however, it is used as hetu in the vākya in PC (on kārikā 17). Cf. tatrānvayādinā svarūpena—. Yd. p. 40, 11.26 f.; p. 44, 1.7. (c) sādhanasvarūpābhīdhanamātram heturiti. Yd. p. 43, 1.24; (d) Svarūpād vītasiddhih. Nyāyāgamānusārinī, p. 313.

to "sapakṣe sattva" as well.⁴
The last part, indicated as 4, is giving an example of the five-membered syllogism. Certainly it starts with a word parallel to "yathā", however we cannot let it go as mere example, because we can find a peculiar way of giving hetu in it. The text gives the three items as hetu and puts an expression indicating "because of suchlike" at their end. It is Sāṃkhya's way to put five reasons even in vākya.⁵ They used to put five reasons as a set of vīta-hetu.⁶ An opponent criticises Sāṃkhya's definition on hetu "sādhanaśamāsavacanam hetuḥ" as Sāṃkhya's hetu is of two (viz., vīta and āvīta), or five kinds, and not brief. According to the opponent's words, it is impossible to use only one reason which is extracted from the collection of the five reasons.⁷ This criticism can be directed to such Sāṃkhya's five reasons in the syllogism as found in Bhavya's "Madhyamakahrdaya". So we can conclude this peculiar type of hetu may be Sāṃkhya's.

Vīta-hetu is formulated into vākya in this way and thus said, "Then, vīta-hetu first leads to establish on the side of a speaker the characteristic of understanding (vijñānasvarūpam) appeared in the intelligence of the speaker himself who impresses others'

teristic of the thing kept in mind properly), Yd. p. 40, 1.26; (b) Svarūpa as asādhāraṇa is said to be of such reason as parimāṇa, anvaya and saṃghātaparārthatva etc. (the last of which is not pakṣadharmatva but is capable of being examined from the point of view of sapakṣe sattva; however, it is used as hetu in the vākya in PC (on kārikā 17). Cf. tatrānvayādinā svarūpena—. Yd. p. 40, 11.26 f.; p. 44, 1.7. (c) sādhanasvarūpābhīdhanamātram heturiti. Yd. p. 43, 1.24; (d) Svarūpād vītasiddhih. Nyāyāgamānusārinī, p. 313.

⁴ Vīta hetu shows the same function as "sapakṣe sattva", tatra sādhanasvarūpābhīdhanamātram heturiti. Yd. p. 40, 11. 25 f. Moreover Uddyotakara uses the idea of avyabhicāraḥ on the explanation of vīta.

tasmād yathānvayino'nvayasambandhavyabhicāraḥ pratipādakāḥ tathā vyatikrino'pi vyatikrāvabhicāra iti/etena yathā vītahetor avyabhi-urā cāriṇa ekasya dharmasya darśanād itaradharmānumānam evam avītahetāvapi ekadharmanivṛttidarśanād itaradharmanivṛtṭyanumānam iti/NV. p. 123, 1.2 from bottom—p. 124, 1.3 cf. Hadano op. cit., p. 191 ff.

⁵ Madhyamakahrdaya, Chap. 6, vv. 25 f. Snar than 252a 11.3-4; Peking ed. 107-2-7-8, Sde dge 234b 11.1f. Hadano, op. cit., p. 202.

⁶ (a) tatra pradhānāstitvasādhane pañcāmī vītaprayogaḥ parair uktah Tattvasaṅgrama hapañjikā, p. 20. (b) tatrāstitvam ekatvaṃ pañcabhir vītaiḥ siddham arthavattvam—Yd. p. 4, 1.15. Cf. Mātharavṛtti, p. 84, 120 —p. 85, 1.1. (c) evam etaiḥ pañcabhir vītaiḥ vyaktasya kāraṇam asty avyaktam iti siddham/Yd. p. 68, 1.19. (d) PC. ad vv. 17, 72.

⁷ Yd. p. 42, 11.18—20; p. 43, 11.22—25. One instance opposite to this idea is found in NV. p. 136, ll 22 f. This opposite instance is a part of a quotation from vasubandhu. (Ui, op. cit., pp. 483 f.)

intelligence; and this vīta-hetu is led into the state of a formulated statement of argument (vākya), since without the formulated statement (vākya) it is impossible for him to lead the meaning into others' intellect. Then the formulated statement of argument (vākya) is supposed to have the parts (tadā'vayavi-vākyaṃ parikalpyate /)".⁸

Now Dignāga's criticism, that whole avayava's are not *reason*, since they belong to vīta and āvīta, can be understood in this context.⁹ That means the collection of avayava's (viz. vākya) is one of the three aspects of hetu in Sāṃkhya and Dignāga criticised Sāṃkhya's view that admits vākya as hetu.

The three things, vīta, āvīta and vākya, of Vārṣaganya¹⁰ are called the three aspects of hetu by "Nyāyasaumya".¹¹ Prof. H. Ui mentioned a name of school parallel to "Nyāyasaumya" from Paramārtha's Chinese version of the commentary on Mahāyāna-saṃgraha.¹² This introduces Sāṃkhya's view as found in Bhavya's Tarkajvālā on Madhyamakahrdaya Chap. 6. 6, too.¹³ Moreover it has become clear that Sāṃkhya-school's teacher as Vindhyavāsin is among "eke naiyayikāḥ", so it is never strange for Sāṃkhya-school to be titled in the connection with Nyāya.¹⁴

So it can be said there is strong possibility for Nyāyasaumya to be one of the Sāṃkhya schools.

ABBREVIATIONS

NV = Nyāyavārttika (Ch. S.S.). PST = Viśālāmalavatī-nāmā-pramāṇasamuccayaṭīkā (ye, No. 4268). PSV = Pramāṇasamuccayaṭīkā (ce, No. 4203). PC = Paramārtha's Chinese version of the commentary on Sāṃkhyakārikā. Yd = Yuktidīpikā. Nyāyāgamānusāriṇī (in Muni Jambuvijaya's edition of "Dvādaśāram Nayacakram with the commentary Nyāyāgamānusāriṇī").

⁸ Yd. p. 40, the last line—p. 41, 1.2. On the relation between vīta and vākya, see Nyāyāgamānusāriṇī, Vol. I, p. 314; Yd. p. 44, 1.5; PSV. Sde dge 54 a 3; PST. Sde dge 193 a 11.5 f.

⁹ PSV. Sde dge 54 a 1.4; PST. Sde dge 193 a 1.7—193 b 1.2.

¹⁰ See E. Frauwallner, Die Erkenntnislehre des klassischen Sāṃkhya-Systems, WZKS Bd. 2, 1958, concerning Vārṣaganya's vīta, āvīta and vākya.

¹¹ Cf. H. Ui: The Vaiśeṣika philosophy, pp. 55 ff; H. Ui: Studies in Indian Philosophy, Vol. I, p. 214, Vol. V, p. 444; K. Yamamoto: Nyaya-suma ni tsuite (Bukkyogaku no shomondai, pp. 480-488); G. Tucci: Pre-Diñnāga Buddhist Texts, XXIX f.; Th. Stehnbatsky: Buddhist Logic, Vol. I, p. 558.

¹² H. Ui: Shodaijoron kenkyu, pp. 276 ff. Taisho-daizokyo, Vol. 31, p. 164c-165a (No. 1595, Vasubandhu's commentary).

¹³ Sde dge Dsa 231 a 11.2—5; Snar than Dsa 248 a 11.4—248 b 1.1; Peking ed. Vol. 96, 105-4-8.

¹⁴ See P. Chakravarti: Origin and Development of the Sāṃkhya System of Thought, p. 193.

In Chapter III and IV of his *Myth and Reality* (Bombay, 1952) Professor Kosambi discussed the evidence of prehistorical and historical survivals gathered during his intensive field research, especially in the Poona district. These fascinating chapters demonstrate the author's grasp over what he called "Combined Methods in Indology"¹ enlisting the assistance of archaeology, history, ethnography, sociology, and philosophy. In support of his views, Professor Kosambi incidentally dealt with the semi-nomadic shepherd sections of the Dhangars in Maharashtra telling us in a very concise manner more about their past than anybody before him. Perhaps this is the occasion to add a few notes on his remarks about Birobā, one of the most widespread and favourite gods of the Dhangars.² "Birobā worship", Kosambi said, "centres somewhere in Sātārā district".³ Actually, a centre of Birobā worship is found at Ārevāḍī near Dhalgāon in the Sangli district where an annual pilgrimage on the fifth till seventh day of the light half of the month Caitra (March-April) attracts 20,000 Dhangars. From Ārevāḍī Birobā has spread to many places in the Sātārā district, as, for instance, to Kuroli Siddheśvar near Dahivāḍī, Pāngri, and Tākevāḍī, where Birobā has assumed the name Sātobā. The Ārevāḍī-Birobā has also wandered into the Poona district and has settled at Bhāde, near the Vīr Dam, and at Kāṭecivāḍī, near Bāramati, and numerous

¹ *IJJ*, VI (1963) 177-202

² The present writer is compiling an account of the history and religion of some semi-nomadic pastoral and settled agricultural sections of the Dhangars of Maharashtra. The intention to work on the Dhangars originated when I had the opportunity to accompany Professor Kosambi on his field research in the years 1959-1960. My own field research was carried out for about 15 months in the years 1967-69. I am grateful to the German Research Association for having granted me financial aid.

³ *Myth and Reality*, p. 121.

other places where Dhangars have their *vāḍi*-s which are seasonal camps or more and more—with the spread of agriculture—permanent settlements. Often the important Birobā temples are situated on migratory tracks, as for instance Ārevāḍi itself, which serves as a camping site on the route of the Dhangars from the Kolhapur area. With the beginnings of the rains these groups take their sheep from the drier East and North-East via Paṇḍharpūr upto Kuḍūvāḍi in the Usmānābād district and return after three months. Before Birobā came to Ārevāḍi he spent his youth in Cinclī, a town 30 miles from Sānglī in Karnatak, in the company of his foster-sisters Ekā and Māyevā. Though Māyevā/Māyākkā/Mhākubāi—Skt. Mahākālī—figures prominently in the traditions of the Dhangars and in the traditions of the corresponding community in Karnatak, the Kurubas, there is nothing about the Dhangars in the locally published *caritra* of this goddess.⁴ According to one set of oral traditions Birobā—after a meandering migration towards the West—arrived at Paṭṭaṇ Kuḍolī, a big village ten miles from Kolhapur, which has developed into a major pilgrimage, the biggest *yātrā* (*jaṭrā*) being celebrated between Dasarā and Divālī on the third day of the dark half of the month Āsvin (September/October). A huge body of oral traditions has accumulated around the Paṭṭaṇ Kuḍolī cult. In Ārevāḍi, and more emphatically in Paṭṭaṇ Kuḍolī Birobā is the younger brother of Iṭṭhal/Viṭhobā of Paṇḍharpūr, and Birobā's *mūrti*, an aniconic stone, is on the left of Iṭṭhal/Viṭhobā's aniconical *mūrti* when facing the devotee.

But we must be careful in making such statements, because there is rarely a singularity of views on the part of the *bhaktas*. Even an individual *bhakta* may offer different explanations at different times. His conception of the deities comprises many beliefs which derive from various social and psychological levels. One *bhakta* would maintain that Viṭhobā is greater from the point of status, because his *bhakti* is more tenacious, but in age Viṭhobā is younger than Birobā. The aniconic stone (*piṇḍ*) of Viṭhobā is smaller in size as compared with that of Birobā's, because the smaller size reflects the modesty of Viṭhobā who becomes great by making others great and does not show off his greatness. Another view of a *bhakta* who comes from far away to the annual *yātrā* is that Viṭhobā is indeed elder than Birobā and he is referred to as *dādā* (elder brother). However the *piṇḍ* in the temple is smaller in size, because Birobā is a greater *bhakta* and there is no dark spot on his character. For

the simple Dhangar in his ovis Viṭhu and Biru are often identical.

Many features of the pastoral Gavḷi Viṭhobā have crept into the traditions of the Dhangars. One such incident is the dispute between Rukmiṇī/Padmāvatī and Viṭhobā which is told in the *Pāṇḍuraṅga-māhātmya* of the *Padma-purāṇa*.⁵ Rukmiṇī had taken offence that Viṭhobā/Kṛṣṇa should still be attached to Rādhā/Rāhī and withdrew to the Diṇḍira-Forest. There, on the site of the present Paṇḍharpūr, Kṛṣṇa found her. The Dhangar/Gavḷi version is told by Durga Bhagwat⁶ and reoccurs in versions from Paṭṭaṇ Kuḍolī, though in a different and less purāṇified guise. Here, like in Paṇḍharpūr the temple of Rukmiṇī, the temple of Kāmabāi, the wife of Birobā in Ārevāḍi, and the temple of Bhāgulek, the daughter of Iṭṭhal/Birobā and his wife Padubāi in Paṭṭaṇ Kuḍolī, are separate.

Birobā or Birāppā is one of the major gods of the Kurubas in Mysore and he is known beyond Bijapur upto Telengana. Considering the wide dissemination of this god it is surprising how little this cult has been thought worthy of study outside the Dhangar community. This may partly stem from the fact that Birobā is often erroneously identified with one of the *bāvan* (fifty-two) *vīr-s*.⁷ As Kosambi correctly states in his *Myth and Reality*: "He [Birobā] should be distinguished from the Māṅg-Vīr cults set up by people of the low Māṅg caste to placate the spirit of some dead adult, just as their Ceḍā is a boy's ghost that refuses to be laid unless given a cult".⁸ These spirits of deceased adults and the *ceḍā* belong to the fifty-two *vīr-s* who are all kinds of spirits as, for instance, malevolent and benevolent *bhūt-s*, *āsura-s*, or minor godlings inhering in idols. The *bāvan vīr-s* are part of the *mantraśāstra* and their study lends the adept the power over them. Gods can have *vīr-s* as their servants and Khaṇḍobā is sometimes said to have fifty-two *vīr-s* under his

⁵ Chapter I of the *Pāṇḍuramga-māhātmyam* [in Marathi], Mumbai Gaṇpatkṛṣṇajī yāmce chapkhānyāce mālaka Ātmarām Kānhobā yāṇim cāpilā āvṛtti 5 vī, śake 1811. Not found in the Veṅkaṭeśvara Press edn.

⁶ *Paṇḍharicā Viṭhobā*, in: Satyakathā, July 1969, 27-31.

⁷ For a list of the fifty-two *vīr-s* see the *Mahārāṣṭra Vākyasampradāy* Koś, Vol. II, Poona, 1947, p. 286. The knowledge about what *bāvan vīr* means is faint amongst the Dhangars. The term is often confused with *bāvan birudem* which means the 52 paraphernalia of a Dhangar, e.g. *tambākhū*, *batvā* (a little bag for keeping tobacco and lime), *kāṭhī* (stick), *ghoṇgaḍī* (blanket), but also the objects connected with cult, e.g. the musical instruments, *ḍhol* (drum), *kaitāl* (cymbals or a kind of castanet), *pavā* (flute), and so on.

⁸ *Ubi cit.*

⁴ Anant Śaṅkar Jośī, Śrī Mahākālī Caritra vā Śrī Cinclī Kṣetra Varṇan, Cinclī vā Morab, 1961.

power.⁹ The priest of a deity may even be able to lend the services of a servant spirit of the deity for some time.¹⁰ It is quite possible that Birobā may have been a *yakṣa* at a time when the Dhangars were a community constantly on the move and not a semi-nomadic group, just an annex to agriculture or even themselves settled farmers. The *Mahāmāyūrī-mantra* mentions Vir as the patron *yakṣa* of the Karhād region.¹¹ But Birobā has long since developed into a full-fledged god with a mythology of his own, temples and important *yātrā*-s. One of the fifty-two *vir*-s is Bhairava/Bahirobā and this fact and the superficial phonetic similarity of Birobā/Bahirobā presumably adds to the identification with Bhairava. Here the matter ends for the *mantraśāstrī*. Ask any educated Maharashtrian with a knowledge of Sanskrit any mythology and he will have no objection to equating Birobā and Bhairava on grounds of external phonetic similarity. And ever since Molesworth compiled his Marathi dictionary we come across the identification with Bhairava "Birobā", Molesworth says, "... A peasant-appellation of the god Bhairav."¹² Bhairava, indeed, is the guardian deity *par excellence* of the Maharashtrian peasant, but is just not a pastoral god. Thus, if one asks a Maratha farmer instead of a Dhangar to show the Birobā temple, one will surely be misdirected to a village Aṣṭa-Bhairav temple which has nothing to do with Birobā. A superficial glance, for instance, at the little village of Bhāde near the Vir Dam in the Purandar Tālukā of the Poona district, where we, like in many other places, find the temple of the Dhangar Birobā at the fringe of the village on a hillock, away from the usual ubiquitous peasant Aṣṭa-Bhairava temple, may not suffice to convince that the cults are distinct. Those Dhangars, however, who are still alive to their history and traditions are emphatic that Birobā has nothing to do with Bhairava. And justly so, because their traditions are quite different.

To illustrate this point one of the versions collected by me in different parts of Maharashtra may be shortly told.¹³ This short

excerpt cannot indicate the wealth of detail, singular beauty and forceful style of the original told by a Dhangar who is a *pūjārī* of Birobā and a factory worker at the same time. Recently he has begun to forget details about the history of Birobā, partly because of an attack of typhoid, but much more so, because he is turning his interest to the texts of the great Sanskrit traditions. He has bought popular Marathi editions of the Mahābhārata and Rāmāyaṇa and has them read to him. He memorizes these texts by heart, turning them eventually into *ovyā*-s which are sung at festivals in his village. In other words, we have a patent instance of how the great traditions slowly erase local traditions. According to this version of the myth, Birobā was born by Sūravantī (Sūryavantī) or Gaṅgā whom Śiva had forgotten in a golden casket on the earth and who on Śiva's command had been afterwards sheltered by the Earth in her womb or rather in an anthill. Eventually the field, including the anthill, was ploughed and the casket was unearthed, followed by flocks and flocks of sheep.¹⁴ The casket was handed over to the king who was without child and who adopted the child. The girl, however, wanted to perform *tapas* in a seven-storeyed *vādā* amidst the jungle. Her *tapas* was so immense that even Śiva was worried and granted her a boon. She desired a child by immaculate conception. Śiva gave her certain tasks to solve, for instance, that she swallow the sun. On her objection that Sūrya was a man, Śiva said that she should wait till the sun had just risen half above the horizon in which case the sun would be neutral. In her *thālī* Śiva put the god Vir in the form of an atom to be incarnated in her. He had been the only one of the 33 crores of gods who was able to complete the study of the *bāvan vir*-s. The conception was discovered and reported to the king. He ordered Sūravantī to be killed and when this proved to be impossible and the child was born from the left side of the mother, the king ordered the child to be killed.

¹⁴ The legends centering around anthills are legion, the anthill invariably being connected with the origin of sheep. Sheep forming a line while being driven from or to the *vādā* strikingly resemble and are actually compared with ants. In connection with the legend told here a legend about the birth of the nephew of Basava, Cennabasava, is of interest: Basava, with his elder sister Nāyalambikā, proceeded to Kalyāṇa to enter the services of the Kalacuri king Bijjala (1156) as a prime minister. When Basava was praying for some gift, he saw an ant emerge from the ground with a small seed in its mouth. Basava took this seed home, and his sister without his knowledge swallowed it and became pregnant. By the interference of Śiva a son was born, who was the incarnation of Śiva in the form of Ṣaṇmukha. See Thurston, *Castes and Tribes of Southern India*, Madras, 1909, Vol. IV, art. Liṅgāyat.

⁹ See R. E. Enthoven, *The Folklore of Bombay*, Oxford, 1924, pp. 193ff., 206. Molesworth, *A Dictionary, Marāṭhi and English*, Bombay, 1857, s. Birobā.

¹⁰ Enthoven, *ubi cit.*

¹¹ Kosambi, *ubi cit.*

¹² Molesworth, *ubi cit.* See also, e.g. S. R. Devle, in *Svarājya*, Nov. 1st, 1968, p. 13: "... Bhairav, Kālbhairav, Bahirobā, Birobā, Dolsobā, Poṭobā, Bhairavnāth hī sarv Kāl Bhairavācī rūpe hot. ..."

¹³ A version of the myth in the *ovī*-form is given in *EK hotā rājā*, ed. Sarojinī Bābar, Mahārāṣṭra Rājya Lokasāhitya Mālā, Puṣpa 10, Mumbai(?), 1964. The myth is also shortly told in: Durgā Bhāgwat, *Lokasāhityācī Rūparekhā*, Mumbai, 1956, p. 405 f.

But the servants of the king only exposed it in the deepest jungle, where even birds could not fly and the sun was so hot that even the stones were parched by the heat. It was the month of Caitra. The crying of the child was heard by Pārvatī and Śaṅkar who descended to provide for the child's needs. Two sisters were created from Śaṅkar's ash and Pārvatī's *kumkum* in the hom altar. The two sisters were to bring up the child. After a long migration the three reached Cinclī in Karnatak.

We need not proceed. At this point of the myth the stage is set for Birobā's numerous adventures, the legends about the spread of his cult, his marriage and his settlement in Ārevāḍī. The episodes have a peculiar semi-pastoral background and show the efforts to come to terms with other deities and settled communities. From the first part of the legend it is already evident that we cannot assign Birobā to the Bhairava mythology of the Purāṇas. Rather, we may see some affinity with Kārttikeya/Śaṇmukha/Skanda of the *Skanda-purāṇa*. Birobā—born by Sūravantī or Gaṅgā—was found in the thicket, just like Skanda—according to one version of the myth of his birth—was “born-in-thicket” (*śara-bhū*). There is a close association of Birobā with the mothers or sisters as in Skanda's case. Birobā was brought up by two foster-sisters who—Dhangars say—are two of the seven mothers. One episode of the myth of Birobā tells us that an old woman, while migrating with her cows, used to carry Birobā on her head in a box. Subsequently her son was killed by Birobā in the form of a snake and merged into Birobā. Full of anger the woman threw the box into an unfathomable pool where Birobā was worshipped by the seven *āsarā-s* (*apsara-s*) for twelve years. The close association with the sisters/mothers is also reflected in the quarrels between Birobā and his wife Kāmābāī, mentioned above; quarrel originated when Birobā, having won his wife after prolonged adventures, preferred to visit the bāzār at Dhalgāon with his sister Māyevā against the entreaties of his wife to stay with her.

There is another contact with the *Skanda-purāṇa*, that is, the *Kāśikhanda* of the *Skanda-purāṇa*. In Chapter 64 of the Marathi version of the *Kāśikhanda*¹⁵ which deals with the establishing of the Vireśvara-līṅga, the story is told how King Mitrajit's wife who was without child was advised to venerate Śiva with sincere *bhakti* on the third day of the light half of the month Mārgaśīrṣa (November/December) in order to bear a child. The child was born, but when the astrologer was consulted about the

child's destiny, it was found that the child was destined to kill its parents. The *mantrī* advised to throw the child into the sea. The queen however wanted the child to be returned to Vikaṭā-gaurī (Śiva's wife) and wanted her to take charge of the child. The child was returned to Vikaṭā-gaurī. She summoned eight *yoginīs* (attendants) who went to Kailāsa and handed over the child to the eight mothers (*mātrkā-s*). The mothers looked after the child for eight years and then returned the child to Gaurī at Kāśī. Gaurī fondled it and called it “Vīr”. One day while it was playing in the temple it was recognized by Bindumādhava (a form of Viṣṇu) as Gaurī's *varaputra* (son granted as a boon). He told Vīr to worship Śiva. Vīr established a *līṅga* and worshipped it for 100 years. Finally Śiva appeared in the *līṅga* and, pleased by the *bhakti* of Vīr, named the *līṅga* Vireśvara-līṅga. This does not mean that the Dhangars have directly borrowed their “Vīr” from the *Kāśikhanda*, but the text is popular in Maharashtra and its diffusion may have helped to contribute towards the formation of the myth of Sūravantī and Birobā. It may be added that in Hunnūr, Tālukā Maṅgaḷveḍhā, district Śolāpūr, the present writer saw a print of the type available in bāzārs near temples, showing Mhālīṅgrāyā Mhālāppā, a famous *bhakta* of Birobā, worshipping Birobā under the name Bireśvarling.

If Birobā is not Bhairava is there any connection between Birobā and Virabhadra? Kosambi said: “However, the Virabhadra of some Purāṇas, supposedly a general of Śiva's army in battle, may reflect the Vir cult”.¹⁶ Indeed wherever Dhangars or especially Kurubars are settled we find that the identification with Virabhadra has made some progress. For instance in Dhotre, Tālukā Puntāmbe, in the Ahmednagar district we find Birobā identical with Virabhadra. Perhaps the identification of Birobā with Virabhadra emanates from Līṅgāyat quarters which had considerable influence in Maharashtra. According to a strong tradition, Khaṇḍobā, the famous Maharashtrian deity worshipped especially by Dhangars, was, like his wife, a Līṅgāyat *vāṇī*; that his second wife Bāṇāī is Dhangar nobody doubts. In many places where Dhangars are settled, e.g. in Huljantī (Maṅgaḷveḍhā Tālukā), where Mhālīṅgrāyā Mhālāppā is chiefly worshipped, and Hunnūr, which has a famous Birobā temple and is connected with Huljantī by many oral traditions, Birobā is considered to be a Līṅgāyat. One of the most important gods of the Līṅgāyats, besides Śiva and Nandī, is Virabhadra. I obtained one version of a Birobā Virabhadra legend from a Kannada booklet entitled

¹⁵ Śivadās Gomā, *Kāśikhanda* [pothī], Nirṇayasāgara Press, Mumbai, 1960, Sanskrit version: Veṅkaṭeśvara Press ed., ch. 83.

¹⁶ *Myth and Reality*, p. 121.

Hālumata Caritra which deals with the religion and history of the Kurubars.¹⁷ Here the demon called Hiranyakaśipu received a boon from Brahmā and he won the three worlds. His overbearing attitude caused the gods to approach Viṣṇu, and he in the form of Narasimha killed him. However, Narasimha's appearance was so dreadful that the people in the world could not bear it. The gods headed by Brahmā came to Śaṅkar and sought for Śaṅkar's advice. Śaṅkar sent Virabhadra and his *gana* in order to pacify Narasimha, or, if necessary, to kill him. Ultimately Narasimha was killed and his head was brought to Śaṅkar who tied it to his neck. As a consequence Mahāviṣṇu was enraged with Virabhadra. When Pārvatī and Śaṅkar were sitting on Kailāsa, Virabhadra approached them and told them that he had the desire to visit the earth. They granted him his wish. Virabhadra took birth in the womb of Sarasvatī, the wife of Brahmā. But Mahāviṣṇu took the form of an old Brahman and appeared before Sarasvatī telling her that the child would have a very bad character and that she should not look at his face. When the child was born Sarasvatī took the child and left it in a burial ground (*śmaśān*). There the birds and animals forgot their animosity and looked after it supplying water and shelter. The deities of the forest pitied the child. Even Agni, Jala, Vāyu, Bhūmi, Akāś, Candra felt pity. A woman named Māyammā came to the *śmaśān*, rescued it and called it Virliṅg. Afterwards, a demon of the Kaśyapa-Gotra, by name Koṇāsūr molested the 700 Kurubars. They approached Virliṅg and asked him to save them. He killed Koṇāsūr at Koṇpūr. The Kurubars became his worshippers and he became their *ādidev* or *kula-daivata*. He is called Vireśvar and he is Virabhadra's incarnation.

Here again we come across Māyammā/Māyevā who finds Virliṅg in a *śmaśān* (instead of in a thicket). Māyevā or Skt. Mahākālī, the foster-sister of Birobā, can also be contemplated to be a kind of sister of Virabhadra, if we follow the *Śiva-purāṇa*, where she is said to be born like Virabhadra from Śaṅkar's matted hair.¹⁸

The picture which emerges leaves little scope for assuming that Birobā is identical with Bhairava at the present stage of the history of Birobā. Even though Dhangars, while singing their *ovyā-s*, occasionally refer to Birobā as "Kāśilinga Birāppā"

and Kāśilinga may refer to Bhairava, and though Dhangars in their *ovyā-s* occasionally refer to Birobā as having the form of Bhairī (Bhairava) they have no explanation for this and there are no legends connected with Bhairava. Eventually the identification of Birobā and Bhairava will make some progress because of the phonetic contamination of Birobā with Bahirobā/Bhairava and because Dhangars will eventually accept and assimilate what *kīrtankār-s*, *ovikar-s*, *gurav-s* and other people more in touch with the great tradition will tell them about their gods. The texts of the great tradition, the Purāṇas, tend to subsume Virabhadra and Bhairava under the terrific aspect of Śiva and in their efforts to abstract and standardize tend to equate Bhairava and Virabhadra, though even in the Purāṇas the causes of the emanations of Virabhadra and Bhairava and their specific tasks are distinct.

¹⁷ Yallangavḍa Ph. Āṭṭikoḷḷa, *Hālumata caritra* [in Kannada], Dhārvaḍ, 1949, pp. 53-55.

¹⁸ *Śivapurāṇa*, *Rudrasamhitā* 2, 32, 22 (25), Veṅkaṭeśvara Press ed. : taj-jaṭāyas-samubhūto virabhadro mahābalaḥ // pūrva-bhāgenā devarṣe mahā-bhimo gaṇagraṇiḥ // 22 // . . . mahākālī samupannā taj-jaṭā-para-bhāgataḥ // 25 //

and
the Gaṇḍavaho¹

In the second Uddyota of the Dhvanyāloka, as an example of atyantatiraskṛtavācya, Ānandavardhana quotes the following Prākṛit Gāthā :

*gaṇam ca mattameham dhārālulijjūṇām a vaṇām
nirahaṅkāramāṅkā haranti nīlāo vi ṇisāo*

“How charming when the clouds reel in the sky ; how lovely when in the woods the white Arjuna trees are torn by great downpours of rain. Though in the sky the moon has lost all pride, yet these black nights have a haunting beauty of their own.”

This verse is number 406 (p. 117) of Vākpatirāja's Prākṛit Mahākāvya, the Gaṇḍavaho. Since Ānandavardhana knew this fine poem,² it is legitimate to ask whether he found anything

¹ Bibliography : Dhvanyāloka with the Locana of Abhinavagupta, and the Bālapriyā of Śrī Rāmaśāraka, ed. by Pandit Pattābhirāma Śāstri, Kashi Sanskrit Series, Banaras, 1940 ; the Gaṇḍavaho, a Prakrit Historical Poem by Vākpati, originally ed. by Shankar Pandurang Pandit, re-edited by Narayan Bapuji Utgikar, Bombay Sanskrit and Prakrit Series No. XXXIV, Bhandarkar Oriental Research Institute, Poona, 1927 ; Kāvya-mīmāṃsā of Rājaśekhara, ed. by C. D. Dalal and Pandit R. A. Sastry, third edition revised and enlarged by K. S. Ramaswami Sastri Siromani, Oriental Institute, Baroda, 1934.

² We do not believe there is any reason for doubting the date of the Gaṇḍavaho, which the editors place in about 700 A.D. (see p. 100 of the Int.). As far as we know, the only source for his date is the remark in the Rājataranginī, quoted in “History of Classical Sanskrit Literature” by K. Krishnamachariar, p. 617) :

*kavivākpatirājaśrībhavabhūtyādisevitah
jito yayau yašovarmā tadguṇastutivanditām*

“Yašovarman when he was conquered (by Lalitāditya of Kashmir) became a praiser of his virtues, he (that is Yašovarman) who was attended upon by the poets Vākpatirāja, Bhavabhūti and others.”

else in the work besides this one verse to inspire him. The answer, we believe, is an unequivocal yes. We wish to point out certain resemblances that have not so far been noted.

The first of these concerns a passage in the second Uddyota, under Kārikā XVI. In explaining the important word *aprthaggyatnanirvartyaḥ*, Ānanda explains that the use of *yamaka* will, of necessity, involve an artificial effort: *rasāṅgatve ca tasya lakṣaṇam apārthaggyatnanirvartyaṭvam iti yo rasam bandhum adhyavasitasya kaver alaṅkāras tām vāsanām atyuhya yatnāntaram āsthitasya niṣpadyate sa na rasāṅgam iti. yamake ca prabandhena buddhipūrvakam kriyamāṇe niyamenaiḥ yatnāntara-parigraha āpatati śabdaviśeṣānveṣaṇarūpaḥ. alaṅkārantareṣv api tattulyam iti cet – maivam. alaṅkārantarāṇ i hi nirūpya-mānadurghaṭāny api rasasamāhitacetasaḥ pratibhānavataḥ kaver ahampūrvikayā parāpatanti.* “The figure of speech that helps the rasa is characterised by the fact that no extra effort is required on the part of the poet to create it (i.e. it arises spontaneously). When a poet has decided to write (a poem that will contain) rasa, should he then disregard (atyuhya) this (main) preoccupation (vāsanā) and engage himself in a further (artificial) effort to produce a figure of speech, then this figure will not prove helpful to rasa. When one intentionally (buddhipūrvakam) and repeatedly (prabandhena) uses *yamaka*, then necessarily an extra (artificial) effort is required in the form of searching for the special words (necessary for the *yamaka*). Should somebody object that this is also true of other figures of speech, we reply that no, in fact it is not. *Because in the case of a poet who is intent upon suggesting rasas and who has imaginative genius (pratibhānavat), even figures of speech which may appear (to the reader) difficult (to create) clamour to present themselves to him !*”³

We can also compare, for an idea not unrelated, the last Kārikā of the fourth Uddyota, Kārikā XVII :

*pratāyantām vāco nimitavividhārthāmṛtarasā
na sādah kartavyaḥ kavibhir anavadye svaviśaye*
(Vṛtti) : (na) santi navāḥ kāvyārthāḥ

*paropanibaddhārthaviracane
na kaścit kaver guṇa iti bhāvayitvā
parasvādānecchāviratamanaso vastu sukaveḥ
sarasvatyevaiṣā ghaṭayati yatheṣṭam bhagavati*

³ Cf. the lovely lines in the Kāvya-mīmāṃsā (p. 62) : *matidarpane kavī-nām viśvam pratiphalati. katham nu vāyam dṛśyamahe iti mahātmanām ahampūrvikayaiva śabdārthāḥ puro dhāvanti.*

“May the words (of poets) in which there is embedded the nectar of many ideas, spread out. In their own blameless task (namely writing), poets should not be despondent.

(Vṛtti): (They should not be despondent), thinking that there are no new poetic themes, (and) for a poet to write about a subject already used by another poet is anything but creditable.

(Kārika contd.) If a good poet is reluctant to use that which belongs to another, the blessed Sarasvatī herself will provide him with (poetic) subject matter as desired.”

Now verse 86 of the Gauḍavaho is similar enough to make us suspect some influence. The verse reads :

attahāloṇanataralā iṇarakāṇam bhāṇanti buddhī
attha ccea nīrāmbhāṇenti hīyayam kaīndāṇam

Here is our Sanskrit translation :

arthālokanataralā itarakavīṇām bhramānti buddhayaḥ
arthā eva nīrāmbham āyānti hṛdayam kavīndrāṇām
“The minds of other (i.e. ordinary) poets wander about frantically searching for subject matter. (But) in the case of great poets the themes themselves rush to their hearts, without any effort on their part.”

The commentator adds: pratibhāṭīśayajanītasamskāra-śayākṛṣṭāḥ santaḥ, (which really stands for samskāra-śayajanīta-pratibhāṭīśayākṛṣṭāḥ).

In the fourth Uddyota, there is a long discussion on ānāntya, the endlessness of poetic themes. Let us quote those verses which are particularly significant :

dhvaner yaḥ saḡuṇibhūtavyaṅgyasyādhvā pradarsītaḥ
anēnāntyam āyāti kavīṇām pratibhāḡuṇaḥ
“Through the treatment of dhvani (proper) as well as (dhvani) where the suggested sense is subordinate (to the literal sense) already given, the quality of poetic imagination becomes endless.”

Kārikā II—

ato hy anyatāṇēpi prakāreṇa vibhūṣitā
vāṇī navatvam āyāti pūrvārthānvayavatī api

“For literature (vāṇī) that is embellished with any one of these varieties (of suggestion) though it reproduce ideas already treated, appears fresh (navatvam).”

Kārikā IV—

drṣṭapūrvā api hy arthāḥ kāvyē rasaparīgrahāt
sarve navā ivābhānti madhumāsa iva drumāḥ

“By using rasa in a poem even subjects seen time and again will appear new, just as do trees in the month of March.”

Kārikā VI—

dhvaner itam ḡuṇibhūtavyaṅgyasya ca samāśrayāt
na kāvyārthavīrāmo ’sti yadīsyāt pratibhāḡuṇaḥ

“By using dhvani and ḡuṇibhūtavyaṅgya in this manner, there will be no end to the subject-matter of poetry as long as there is the gift of poetic imagination.”

The Kārikākāra then goes on to show that this same endlessness is equally possible in the case of the literal sense (vācyārtha) as well (and not only in the case of the suggested sense) :

Kārikā VII—

avasthādeśakālādivīṣeṣair api jāyate
ānāntyam eva vācyasya śuddhasyāpi svabhāvataḥ

“By its very nature (svabhāvataḥ) (i.e. even without the help of a suggested sense), the purely denoted sense is inexhaustible because of differences of circumstance (avasthā), place (deśa), time (kāla) etc.”

Kārikā IX and X—

rasabhāvādisambaddhā yady aucityānusārīṇī
anvīyate vastugatir deśakālādibhedīṇī

(Vṛtti): tat kā ḡaṇanā kavīṇām anyeṣām parimitaśaktīṇām
vācaspatīśaśrāṇām sahasrair api yatnataḥ
nibaddhā sā kṣayam naitī prakṛtir jagatām iva

“If the subject-matter (vastugati) that is diversified according to time, place, etc., is used in accordance with (the doctrine) of propriety and is associated with rasa, bhāva, etc.

(Vṛtti): How can we even consider other poets of limited power (when) :

“Though assiduously written about by thousands of thousands of (poets similar to) Vācaspati, it cannot be exhausted any more than the primordial matter (prakṛti) of the universe.”⁴

Now this discussion leads to the topic of plagiarism, which, it has been thought, the Dhvanyāloka was the first to formulate, in Kārikās XI, XII, XIII, XIV and XV. The verse that interests us the most is Kārikā XVI :

*yad api tad api ramyam yatra lokasya kiñcit
sphuritam idam itīyam buddhir abhyujjihīte*

(Vṛtti): *sphuraṇeyam kācid iti sahrdayānām camatkṛtir
utpadyate*

*anugataṃ api pūrvacchāyayā vastu tādrk
sukavir upanibadhnān nindiyatām nopayāti*

“Any theme whatsoever will be beautiful even though it resembles a previously existing (one) as long as the thought arises in the minds of people that : ‘This is ineffably quivering (with beauty)’. It can be used by a good poet without his incurring any blame.

(Vṛtti) : ‘O, this is ineffably vibrating !’

This aesthetic rapture (camatkṛti) is produced in the case of sensitive readers.

Here now are the verses from Vākpatirāja’s Gaṇḍavaho that almost certainly influenced Ānandavardhana or the author of the Kārikās that we have cited above :

Verse 84 :

*kālaguṇā paḍhamakāiḥ bhamiyam apariggaḥesu maggesu
iharā māiḥ hīranti dukkaram ke vikāṇam pi*

Here is our Sanskrit translation :

*kālaguṇāt prathamakavibhir bhrāntam aparigraḥesu mārgeṣu
itare matibhir hriyante duṣkaram ke ’pi keṣām api*

“Earlier poets, through the virtue of their times (i.e. because they were born in ancient times) were able to wander on

⁴ Cf. D. Āl., Vṛtti, p. 526 : yasya rasāder āśrayād ayam kāvyamārgaḥ purāṇaiḥ kavibhiḥ sahasrasamkhyair asamkhyair vā bahuprakāram kṣuṇṇatvān mito ’py anatatām eti. “By having recourse to the use of dhvani consisting of rasa, etc., this path of poetry which is otherwise limited in the sense that it has been trodden in many ways by thousands or even a countless number of older poets, achieves endlessness.

virgin paths. But some (ke ’pi) others (itare) (i.e. modern poets) need hardly ever (duṣkaram) do so, for they are guided (hriyante), thanks to the time they live in, by the vision of earlier poets.”⁵

Verse 85 :

*katto nāma na diṭṭham saccam kaiseviesu maggesu
sīmante uṇa mukkammi tammi savvam navamcea*

Here is our Sanskrit translation :

*kuto nāma na drṣṭam satyam kaviseviteṣu mārgeṣu
sīmānte punar mukte tasmin sarvam navam caiva*

“It is true that there is nothing that has not been seen on the well-trodden paths of poetry. But actually this is true for only the very beginnings of the path. All else is new.”⁶

⁵ This verse is not without its obscurities. The commentator seems to think that the first kālaguṇāt is meant negatively, i.e., that earlier poets were forced to travel on unbeaten paths : . . . vyāmoho ’nubhūtaḥ kāladoṣāt, and that modern poets have the advantage of moving along a path where the way is already cleared : . . . naiva bhramyate drṣṭapūrvakavikalpitamārgatvāt athavā kṛtavāgdvāra iti nayena (a reference to Raghuvamśa I. 4.). But the context is really the opposite, of the difficulties of modern poets who must use material already well-sifted. Perhaps the idea is a double one : not only need the poet not worry about travelling along well-beaten tracks, it is even an advantage, for he need not make the same mistakes of older poets who had no guides.

⁶ This verse too is obscure. What does sīmānta mean? Professor N. G. Suru, who is preparing a translation of the Gaṇḍavaho translates this verse as follows :

“How could any thing (topic) escape observation (of the earlier poets) on the paths (of vision) followed by them (thus leaving practically no topic for moderners to poetise)? True. If, however, the (traditional and conventional) borderlines be given up (and the horizons of imagination be widened), all (topics) will be just as fresh and new even to him (the modern poet).”

Professor Suru’s translation, along with a new edition of the text, will soon appear in the publications of the Prākṛit Text Society, Ahmedabad. We are grateful to him for allowing us to see his work before publication.

Another translation, different from both of these, is possible as follows :

“What truth (originality) possibly is not seen in the paths followed by (modern) poets? But if the utmost (extreme) limit (sīmānta) is left out (given up), everything there (i.e. in the poetry of modern poets) is new (original).”

This renders sīmānta by extreme or utmost limit, i.e., extreme view, extremist views about originality.

Verse 87 :

*āsamsāram kaipuṅgavehi taddiyahagahiyasāro vi
ajja vi abhinṇamuddo vva jayal vāyāparipphando*

Here is our Sanskrit translation :

*āsamsāram kavipuṅgavais taddivasagrhitasāro 'pi
adyāpi abhinṇamudra iva jayati vācāpariṣpandaḥ*
"Glorious is the poet's speech pulsating with inspiration !
Though every day great poets have drained its essence from
the beginning of creation (and will continue to do so until
the end of time) yet it still seems as if its seal remains
unbroken (i.e. its riches have barely been tapped)."⁷

Finally, we wonder whether, when Ānandavardhana, on p. 527
of the fourth Uddyota of the D. Āl. quotes a Gāthā by a certain
"great poet" (gāthā cātra kṛtaiva mahākavinā), the reference is
not to a lost poem of Vākpatirāja. The Prākṛit reads :

*atahaṭṭhie vi tahaṣaṇṭhie vva hiaammi jā nivesei
atthavisese sā jaai viadakaigoarā vāṇi*
(*atathāsithān api tathāsamsthitān iva hṛdaye ya niveśayati
arthaviśeśān sā jayati vikāṭakavigocarā vāṇi*)
"The literary art of great poets is all-conquering. For it
causes various ideas to enter the heart (of the reader) and
appear (there) in a form which is different, as it were, from
their real form."⁸

We can compare this with stanza 66 of the Gauḍavaho :

*ṭhiyam aṭṭhiyam va dīśai aṭhiyam pi pariṭṭhiyam va paḍihāi
jahasaṇṭhiyam ca dīśai sukaṇṇa imāom payaṇo*

⁷ This verse is quoted by Rājaśekhara (p. 62) right after his sūtra
on plagiarism (Adhyāya XII). First he quotes the "ācāryas":
purāṇakavikṣuṇṇe vartmani durāpam asprṣṭam vastu, tataś ca tad
eva samskartum prayateta, ity ācāryāḥ.

"On the path followed by older poets, it is difficult to come across
something (a subject) that has not already been dealt with. Therefore
(a modern poet) should attempt only to refine those (very same sub-
jects). This is the opinion of the venerable teachers."

He then says that Vākpatirāja disagrees (na, iti vākpatirājāḥ).

*āsamsāram udāraiḥ kavibhiḥ pratidinagrhitasāro 'pi
adyāpy abhinṇamudro vibhāti vācām pariṣpandaḥ*

⁸ Cf. also p. 498 of the third Uddyota of the D. Āl. :

*bhāvān acetanān api cetanavac cetanān acetanavat
vyavahārayati yatheṣṭham sukaviḥ kāvye svatantratrayā*

Our Sanskrit translation is :

*sthitam asthitam iva dṛśyate asthitam api pratiṣṭhitam iva
pratibhāti*
yathāsamsthitam ca dṛśyate sukavīnām imāḥ prakṛtayaḥ
"What is real appears as unreal and what is unreal appears
as if it were real, and (sometimes) a thing appears exactly
as it is—these are the ways (prakṛtayaḥ or padavyaḥ) of
good poets."

It is thus not only clear that Ānanda or the Kārikāra knew
the Gauḍavaho and quoted one verse from the poem, but also
that several of his most cherished ideas come from this great
work.⁹

⁹ A final, very speculative remark, suggests itself to us : is it at all
possible that the borrowing is the other way round ? We believe that
the Kārikās are not by Ānandavardhana, but by an older writer. Could
they be old enough for Vākpatirāja to have utilised them in writing his
Gauḍavaho ? Note the final verse of the D. Āl., by Ānandavardhana
himself (p. 552-553) :

*satkāvyatattvanayavartma ciraprasupta-
kalpam manassu paripakvadhiyām yad āsit
tad vyākarot saḥṛdayodayalābhahetor
ānandavardhana iti prathitābhidhānaḥ*

"The famous Ānandavardhana explained that (dhvani), the path
to the exact knowledge (naya) of the essence of good poetry, which
was practically (kalpa) dormant in the minds of (even) those of
mature intelligence (paripakvadhiyām), for the sake of giving
delight to those sensitive to literature."

Now the word vyākarot is important, for, as far as we know, it is
used primarily to denote an explanation of something already expounded
and is not used to expound a totally new theory. Moreover, tad (Bāla-
priyā : dhvanisvarūpam) was ciraprasuptakalpam. Surely this means
that it existed previously. It cannot be taken to mean that dhvani was
simply not used for a long time (which is the way some modern com-
mentators on the D. Āl. take it), since Ānanda's numerous quotations
from near-contemporary sources belie this. It must mean that the actual
doctrine (from the time of the Kārikākāra) had not been in vogue !
Paripakvadhiyām is further evidence. It cannot, in the circumstances,
refer to poets, for the same reason as given above. Therefore it must
refer to theorists, and points to the earlier existence of a dhvani theory.

Method and Indian Chronology*

I

Astronomy is a very exact science. The accuracy with which measurements in astronomy can be made is most remarkable. Thus, astronomers have been able to measure exactly the precession of the perihelion of Mercury which is a few seconds of angle in a century. Similarly, the precession of the equinoxes which is about 50 seconds per year is accurately known. If, therefore, astronomical data be found in ancient Indian literature and if they are capable of being used for exact calculations, the results must be very reliable indeed. This method could then be considered a powerful tool in dating events, that is to say, in chronology. Workers of the last century like Tilak¹ and Dikshit² used it very effectively. And yet, many eminent Indologists of later times do not attach much value to this method. It would appear to have fallen into disfavour.

It is the purpose of this essay to consider what the method is capable of and also how it could be, and has been, misused.

II

Perhaps the most commonly used astronomical tool, for dating, has been the precession of the equinoxes. The equinox or the

* This paper is a revised version of one in the "Sri Venkatesvara University Oriental Journal."

¹ Tilak, B. G. *The Orion or Researches into the Antiquity of the Vedas*. Fourth edition, 1955. Tilak has "endeavoured to show that the traditions recorded in the R̥gveda unmistakably point to a period not later than 4000 B.C., when the vernal equinox was in Orion".

² Dikshit, S. B. *History of Indian Astronomy in Marathi*. New edition 1931, pp. 127-129. Dikshit has used certain statements in the Śatapatha Brāhmaṇa regarding the nakṣatra Kṛttikā to determine the date of that work.

solstitial colure is located in a certain asterism at a given time. Because of precession it moves back through the asterisms. The exact rate of precession is known. The present situation is known. What could be easier than to work out a date if a reference to the situation then is discovered in some ancient book? But in making such calculations and drawing conclusions from them there are pitfalls that have to be guarded against. Let us consider some of these :

1. Suppose, an author like Varāhamihira gives some information about the situation of the solstitial colure.³ One could calculate exactly when this event occurred. But the date arrived at could not be accepted as the date of Varāhamihira unless the information is known to be strictly valid at the time of the author. Firstly, as difference of one degree in the situation of the colure amounts to 72 years in time and if the date of an author is expressed correct to a multiple of 72 it hardly has any value. Secondly, there is always a possibility that the information given by the author may be traditional and not a result of observation. This point will be easily appreciated if we remember that the data we use today for the situation of the equinoxes in our Pancāngas, is about 1500 years old! Dates calculated on the basis of such data would be meaningless.

Sir William Jones⁴ was perhaps the first western scholar to use this method to assign a date to Varāhamihira. He uses Varāha's data and arrives at a date which, it must be admitted, is not far wrong. Colebrooke,⁵ on the other hand, uses some other information from Varāhamihira's Bṛhatsamhitā and get two dates, differing by 224 years, and then takes the mean as the real date! True, again, the date obtained is eminently satisfactory, but, the method? What is more, Colebrooke⁶ has in another place using yet another piece of information from the same book attributed to the same Varāhamihira a date differing from the above by 120 years!

2. The rate of precession of the equinoxes is known accurately

³ See Bṛhatsamhitā III. 2 where he says 'At present one ayana of the Sun begins from the commencement of Karkaṭaka and the other from the commencement of Makara'.

⁴ See *The Works of Sir William Jones*, Vol. IV. Jones's calculation gives the same year as was mentioned by Āryabhaṭa I as the one when he was 23 years old. The quotation from Bṛhatsamhitā in note 3 above was, in fact, the basis of Jones's calculation.

⁵ Colebrooke, H. T. *Algebra, with Arithmetic and Mensuration, from the Sanskrit of Brahmagupta and Bhāskara*, 1817.

⁶ *Miscellaneous Essays by H. T. Colebrooke*, edited by his son Sir T. E. Colebrooke, Vol. III, p. 317.

at present. The values given by ancient Indian astronomers are not very correct. If one wishes to work out a date by this method, in relation to the present, the correct rate must be used. If one uses the value given by the *Grahalāghava*, for example, (which reckons precession at 60" a year) reliable results should not be expected. The use of an inaccurate rate, given by some ancient author would be justified only when one wishes to check conclusions of that author based on his own rate of precession.

3. The subject of precession is closely linked to the commencement of the asterisms. A particular asterism is designated as the first. In ancient times these asterisms were the actual star groups in the heavens. Today they are the 27 divisions of the ecliptic. A research worker must know precisely whether he is dealing with the star groups or the divisions. He is not allowed to mix up the two ideas in one and the same work.

Further, when one is dealing with, say, the *Kṛttikā* period (i.e. the period when *Kṛttikā* was the first asterism) he cannot arrive at a valid conclusion if he assumes *Aśvinī* to be the first asterism, as it is today. This error was committed by Cunningham,⁷ in his *Book of Indian Eras*, where he assumed *Maghā* to be the *tenth* Nakṣatra at the beginning of Kali Yuga. This means he assumed *Aśvinī* to be the first Nakṣatra in the year 3102 B.C. The antiquity of the *Saptarṣi kālā* which he derived from these considerations could hardly be called reliable.

4. Another consequence of precession is the change in the pole of the celestial equator. The second magnitude star, α -Ursae Minoris, which is very near to the north pole today and is called the pole star could not have been so in, say, 3000 B.C. Any conclusion based on the assumption that it was is sure to be wrong. (Jacobi⁸ has pointed out—a look at a star map would also be enough—that α -Draconis must have been the pole star about this time.)

III

It would not be altogether out of place here to indicate how other astronomical or mathematical methods may be unsatisfactory in their own way.

1. When dealing with literature of a particular period, if astronomical references in it are to be used, it is necessary to see that

⁷ Cunningham, A. *Book of Indian Eras*, 1883. Chapter I entitled 'Saptarṣikālā'.

⁸ See, for example, G. R. Kaye. *Hindu Astronomy*, 1924, p. 31.

the scholar does not assume more knowledge on the part of the author than was possible at his time. The *Ṛgveda saṁhitā*, for example, mentions very few Nakṣatras by name. There is no evidence that all the 27 (or 28) Nakṣatras were devised and designated at that time. It would be wrong, then, to derive any chronological conclusion on the assumption that all the Nakṣatras were known then as they are today.

2. A very common pitfall in chronology, difficult to detect, is anachronism. The procedure quoted in 1 above really falls in this class. But more glaring errors can be, and have been, committed, for instance, when Purāṇic literature is used for Vedic chronology. Thus, Daftari⁹ makes use of certain statements in the *Vāyu Purāṇa* and other texts to determine the period of composition of the *Ṛgveda*. With this and other considerations he comes to the very bold conclusion, "that *Ṛgveda* was being composed regularly every fourth year, most probably, between 3102 B.C. and 1300 B.C. with breaks".

B. R. Kulkarni¹⁰ is a very sound scholar who is keenly conscious of the error of anachronism. All the same his identification of celestial Nakṣatras from the Nakṣatra devatās in *Ṛgvedic* hymns does not appear permissible to me. A full list of Nakṣatras and the corresponding deities appears first in the *Taittirīya-saṁhitā* and then in the *Vedāṅga-Jyautiṣa*. As I have remarked above few Nakṣatras are mentioned in the *Ṛgveda*; what is more, names of the Devatās, which later came to be associated with the Nakṣatras, are met with frequently in *Ṛgveda* as deities unconnected with astronomy.

3. It is only when the astronomical information available, from a text, to a scholar leaves no room for the scholar's personal interpretation that reliable results may be expected. In every other case it is highly desirable that the results obtained mathematically be compared with those available from other sources—historical, philological, etc.

Bentley,¹¹ an Orientalist of the early years of the last century, came to the conclusion that Varāhamihira lived in the 16th century A.D.—ignoring the fact that Alberuni, who visited India in the 11th century A.D. dwells at considerable length in describing the works and opinions of Varāhamihira. (Bentley, it is said, did not understand Sanskrit.)

⁹ Daftari, K. L. *Astronomical Method and its Application to the Chronology of Ancient India*, 1942, p. 241.

¹⁰ Kulkarni, B. R. *Astronomical Clues for Chronology in Ṛgveda*, in Marathi, 1952, p. 51.

¹¹ See, for example, Kern, H. *Bṛhatsaṁhitā*, 1865. Introduction, p. 3, footnote.

4. A favourite procedure with orientalist wishing to derive the date of an event is to go back to the event from a known date by specifying the generations that are said to have passed between the two events and allotting a certain number of years to each generation. This is a daring procedure and could at best give a very very rough date. What is more, different workers allot different years per generation according to their individual preference. It is difficult to resist a feeling that the individual preference is guided by a prejudged result. Thus, Kane¹² using the data contained in the Nidhanpur plates of Bhāskara-varman arrives at a date for the Mahābhārata war on the basis of 20 years for each generation of rulers. This brings him to a date very close to that given by Varāhamihira for that event.¹³ On the other hand Daftari¹⁴ taking one generation to be equal to 22 years proves (?) that the Dvāpara yuga is equal to 200 years.

The method is, indeed, reminiscent of that adopted by Max Müller¹⁵ in deriving his vedic chronology in which he breaks up Vedic literature into four periods and assigns 200 years to each period. Max Müller himself says, "We can do so only under the supposition that during the early periods of history the growth of the human mind was more luxuriant than in later times."

5. The period from the early years of the Śaka era to very recent times has been called Jyotin-siddhānta kāla by S. B. Dikshit.² Some authors of this period have used symbolic words to represent numerals. Thus, *Netra* means two; *Veda* is four, *Rasa*—six etc. Āryabhaṭa-I as well as Āryabhaṭa-II used letters of the alphabet for the same purpose, but with a different sense. For example, *Bu* according to the first Āryabhaṭa would be 230,000 but in the notation of the second Āryabhaṭa it is just 4. Now, when manuscripts were copied time and again, by scribes who were rarely astronomers, the possibility of change in some of the letters was always there. This would lead to an error in the figures representing numerical data. A clear case of such an error has been pointed out by Dikshit¹⁶ in his *History of Indian Astronomy*. Such errors could be detected only by reference to tradition, comparison with other treatises etc. Otherwise the

data would be of no reliable use.

6. Perhaps the most hackneyed theme on which scholars have dissipated considerable amount of energy is the determination of the year of the Bhārata war. The basis for this research is the astronomical data picked up from the Mahābhārata. The result of the research is that almost every worker gets a different year for the event. To give just three examples, Daftari¹⁷ puts the war in 1197 B.C., Ketkar¹⁸ in 258 B.C., R. V. Vaidya¹⁹ in 2786 B.C. In spite of such wide differences of opinion some scholars are so confident of their own approach that they claim to know the exact dates of individual events of the war.

In my opinion the main difficulty in work of this kind arises out of the acceptance of the astronomical data from purāṇic and epic literature at its face value. It should not be difficult to realise that astronomical reference in these works are only incidental. There is no need to suppose that they are a result of actual observations taken at the time of the war. They may have been introduced just to give an astrological aura to the composition. Later interpolations, too, cannot be ruled out. The result is conflicting statements which the scholar tries to reconcile in his own way and derives his own date for the Bhārata war.

¹² Kane, P. V. *History of Dharmaśāstra*, 1946, Vol. III, p. 898.

¹³ See paper by author on *The Date of Varāhamihira Ann. B.O.R.I. Golden Jubilee Volume*.

¹⁴ *Loc. cit.*, p. 152.

¹⁵ See, for example, Ghate, V. S. *Lectures on Ṛgveda*. Lecture XIII 'Age of Rigveda'.

¹⁶ *Loc. cit.*, p. 192. Dikshit here points out how Kern in editing the *Āryasiddhānta* of Āryabhaṭa II has misread *śu* for *bu* leading to an error of 570,000 in the number of revolution of the earth in a Mahāyuga.

¹⁷ *Loc. cit.*, p. 124.

¹⁸ Referred to in Dikshit, *loc. cit.* p. 124.

¹⁹ Vaidya, R. V. *Bhāratiya yuddhakālanirṇaya* in Marathi, 1964.

Part II

**Papers in Science
including Mathematics**

1 Steps in Science

D. D. Kosambi

1. Why science ?

The question 'Why solve problems?' is psychological. It is as necessary for some of us as breathing. Why scientific problems, not theology, or literary effort, or some form of artistic expression? Many practising scientists never work the answer out consciously. A few centuries ago, questions of religious philosophy and theology ruled supreme for the intelligentsia of many countries. Those lands where the leading intellectuals persisted in these speculations remained ignorant, backward and were progressively enslaved (like India) in spite of a millennial culture. No advance was possible out of this decay without a modern technique of production, towards which the intellectual's main contribution was through science. There is a deeper relationship : Science is the cognition of necessity; freedom is the recognition of necessity. Science is also the history of science. What is essential is absorbed into the general body of human knowledge, to become technique. No scientist doubts Newton's towering achievement; virtually no scientist ever reads Newton's original writings. A good undergraduate commands decidedly more physics and mathematics than was known to Newton, but which could not have developed without Newton's researches. This cumulative effect links science to the technology of mechanised production (where machines save immense labour by accumulating previous labour) to give science its matchless social power, in contrast to art and literature with their direct personal appeal. Archimedes, Newton, Gauss form a chain wherein each link is connected in some way to the preceding; the discoveries of the later would not have been possible without the earlier. Shakespeare does not imply the pre-existence of Aeschylus or of

Kalidasa; each of these three has an independent status. For that very reason, drama has advanced far less from the Greeks to the present day than has mathematics or science in general. The earliest statues of Egypt and Greece, the first known Chinese bronzes, show a technical mastery of the material and of art forms that make them masterpieces even now, though the artists remain unknown; but the technique is not linked to production as such, hence not cumulative. The artist therefore survives if and only if his name remains attached to some work that people of later ages can appreciate. The scientist, even when his name be forgotten, has only to make some original contribution, however small, to be able to say with more truth than the poet, 'I shall not wholly die, the greater part of me will escape Libitina.' The most bitter theological questions were argued out with the sword; for science, we have the pragmatic test, experiment, which is more civilized except when some well-paid pseudo-scientist wishes to 'experiment' with thermo-nuclear weapons or bacterial warfare.

2. Natural philosophy

I went to school and college in the USA. It was obligatory to learn several European languages in school and college. The libraries were unquestionably the best in the world for accessibility and range of books. Alexander von Humboldt's *Cosmos* surveyed the whole universe known to the nineteenth century, from the surface of the earth to those mysterious prawn-shaped figures visible through the most powerful telescopes, the spiral nebulae. The Einstein theory, arousing passions of theological intensity, had just been regarded as proved, and offered new insight into the structure of space and time. Innumerable outlines made it easy to learn something about every branch of science. Freud had taught men to take an honest look at their own minds. H. G. Wells showed through his *Outline of History* how much the professional annalistic historian had to learn. The inspiring lives of Pasteur and Claude Bernard proved that man could gain new freedom from disease through the laboratory; the deadliest poison became a tool for the saving of life through investigation of the body's functions. Such were the real *r̥sis* and *bodhisattvas* of modern times, the sages whose social achievement added to man's stature. This contrasted with the supposed individual perfection of mythical Indian sages, expressed in incomprehensible language and fantastically interpreted

by commentators. It is fatally easy to preach about the spiritual superiority of India to the materialistic West; the ability to replace incomprehensible Sanskrit words by still longer and equally meaningless English terms can make a prosperous career.

Engineering is based upon physics and chemistry, which are qualified as 'exact sciences' precisely because they admitted a mathematical basis. No other discipline unlocked the door to the atom or to the movement of celestial bodies equally well, as mathematics did. Aptitude granted, mathematical research needed the least financial resources of any science. However, I chose mathematics because I could not resist its fascination. Mathematical results possess a clarity and give an intellectual satisfaction above any others. They have absolute validity in their own domain, due to the rigorous logical process involved, independent of experimental verification upon which applications to the exact sciences must depend. Mathematics was the language of nature, *scientiarum clavis et porta* as Roger Bacon put it.

Unfortunately, not every kind of mathematics unlocks every door to nature's secrets. For some twenty years, my main work lay in tensor analysis and pathgeometry (my own term). Though fundamental for the theory of relativity, the discipline is of interest only to a few specialists. In 1949, Einstein pointed out to me during one of several long and highly involved private technical discussions that certain beautifully formulated theories of his would mean that the whole universe consisted of no more than two charged particles. Then he added with a rueful smile, 'Perhaps I have been working on the wrong lines, and nature does not obey differential equations after all'. If a scientist of his rank could face the possibility that his entire life-work might have to be discarded, could I insist that the theorems whose inner beauty brought me so much pleasure after heavy toil must be of profound significance in natural philosophy? Fashions change quickly in physics where theory is so rapidly outstripped by experiment. It seemed and still seems to me that non-associative linear algebras and Markov chains would remove many of the physicists' theoretical difficulties; the experimenters are satisfied with abandoning the principle of parity. The 'red shift' of distant stars will perhaps be explained one day as due to the absorption of energy when light travels at cosmic distances through extremely tenuous matter, not as evidence for an expanding universe. Such speculations are of no use unless tallied

in mathematical detail with observed data.

3. *Chance and certainty*

Borderline phenomena of classical physics illustrate the inexhaustibility of the properties of matter. Ice, according to the textbooks, melts and water freezes at zero degrees Centigrade. But when carefully purified samples of water are slowly cooled and the ice slowly melted again, a considerable gap is found between the melting and freezing points. Fundamental particles that make up the atom and its nucleus show another type of aberrant behaviour. An electron can cross a potential barrier, as if a stone were of itself to roll uphill against gravity, and down the other side. Even the observation of isolated particles becomes difficult, for the very act of observation means some interaction and effect upon the observable. The certainty of classical physics comes only when many fundamental particles are organized into higher units with clear patterns. In the same way, individual molecules of water may move in any direction with almost any speed, but the river as a whole shows directed motion in spite of eddies. So also for aggregates of living matter. In human society, the net behaviour of the group smooths out the vagaries of individual action.

The mathematical analysis best suited for handling such aggregates is the theory of probability, the estimation of chances. Variation is as important a characteristic of the collective as the mean value. Prediction can only be made to within a certain probability, which sounds like the language of the race course. But when the chances of a mistake amount to one in a million, most people take the effect as certain. The level of significance desired may be personal matter. For example, there is a chance of a letter being lost in the mail; whether or not we register or insure it depends upon our estimate of the risk involved, and the expectation of loss. Thus, modern statistical method can be an excellent guide to action. It extends the assurance of exact science to biological and social sciences. Though no man can say when death will come to him, as it certainly must to all men, it is fairly easy to predict within a reasonable margin of error about how many men out of a large group will die after a set number of years. That is why life insurance manages to be a highly paying business, without recourse to astrology. It is further possible to say how the occupation and living conditions affect longevity. The man who has to

work in a lead mine (without special protection) has his expectation of life reduced by a predictable number of years, more surely than those shot at by lead bullets on the battlefield.

The method of proof for deductions based upon probability differ radically from those of pure mathematics. Conclusions cannot be 'true or false' without qualification, when the variation inherent in the trials is assessed. The standard method is to set up a 'null hypothesis', take the observed results as due to purely random independent variation. The theory suitably applied (and the application needs profound grasp) then gives one of two conclusions: that the numerical observations are compatible with the hypothesis; or not. But either conclusion would be true only with a certain calculable probability, which tells us about how often we would go wrong in action. The trick is to set up the experiment in such a way that the desired action may be taken if the null hypothesis is contradicted; for, incompatibility implies falsehood whereas compatibility need not imply truth.

This leads to difficulties in dealing with phenomena where the experimenter's will to believe is stronger than his common sense. Parapsychologists test *ESP*, 'extra-sensory perception' (such as telepathy) by having two people match cards at a distance. The effect is so faint and irregular as to call for recondite statistical tests, which apply on the null hypothesis that the matching could have been obtained by mere chance. The tests then show that the chances are very small, wherefore the parapsychologists claim victory. The null-hypothesis is contradicted, but the reason given is not necessarily true. Shuffling the cards does not randomize them efficiently, i.e. pure chance is not fully effective. There are excellent statistical tests for such randomization, and it was shown by my own experiments that the kind of shuffling practised for *ESP* is inefficient when judged by the same kind of statistics that is applied to card-matching. Cards originally next to each other tend too often to stick together. Claims for *ESP* would be more convincing if one produced supplementary evidence (say matching encephalograms for sender and receiver) for a physical mechanism of transmission. Some regard the effect as beyond the normal sensation, transcendental, not accessible to material analysis. In that case, there is no logic in any laboratory tests; the statistical 'proof' becomes mere ritual.

One of my theoretical papers deals with probability and

statistics in infinitely many dimensions. There has been no effective use, because the attempts at getting a special electronic calculating machine to translate this theory into practice failed. No one with the requisite resources has yet felt the need. On the other hand, a paper on genetics was unexpectedly successful. Professional geneticists use it for all kinds of investigations, such as heredity in house mice. It seems to have given a new lease of life to genetical theories which I, personally, should like to see revised; so that I am accused at times of not appreciating my own formula. It would have been pleasant to see the formula applied to the increase of food production; but the pure scientists of a country which grows the world's greatest food surpluses and destroys them to keep grain prices high in a hungry world sneer at 'clever gardening'. There is some difference of opinion here as regards the proper relation of theory to practice.

4. Ancient Indian culture

To teach myself statistics, I had to take up some practical problems from the very beginning. One such was the study of examination marks of students. It turned out that even the easiest of examinations in India (the first-year college examination) was based on a standard that differed from that of the instruction, if in twenty-five years no student of the 90% or more who passed could score more than 82% overall while the professors who taught and examined had scored much less in their own time. Improvement of the system (whether in examination or instruction) was out of the question in a country where the teaching profession is the waste-basket of all others, and the medium of higher instruction is still a foreign language.

A more fruitful problem was the statistical study of punch-marked coins. It turned out that the apparently crude bits of 'shroff-marked' silver were coins as carefully weighed as modern machine-minted rupees. The effect of circulation on any metal currency is obviously to decrease the average weight in proportion to the time and to increase the variation in weight. The theory of this 'homogeneous random process' is well known, but its applications need careful work on whole groups of coins. Moreover, it is necessary that the history of the coins be closed in antiquity, at one time; this means deposit in a well-preserved hoard. The main groups of punch-marked coins in the larger Taxila Hoard could be arranged in definite chronological order,

the oldest groups being the lightest in average weight. There seems to have been a fairly regular system of checking the coins in antiquity. As control, I personally weighed over 7,000 modern coins (taken from circulation) one by one, on slow analytic balances. It was then possible to lay the foundations of numismatics as a science, as contrasted to a branch of epigraphy and archaeology. Taxilan economy of the period was beautifully revealed by the coins though the coins bore no legends.

Arranging coin-groups in order of time led naturally to the question: Who struck these coins? The hoard was dated to about ten years after Alexander's death. But who were the Indian kings, if any, who left the marks on the coins? The written sources display a shocking discordance. The *Purāṇas*, Buddhist and Jain records often give different names for the same king. Study of the records meant some mastery of Sanskrit, of which I had absorbed a little through the pores without regular study. Other preoccupations made it impossible to spend as much time as the average student on the classical idiom. So, the same method was adopted as for study of statistics: to take up a specific work, of which the simplest was Bhartṛhari's epigrams (*subhāṣitas*). The supposed philosophy of Bhartṛhari, as glorified by the commentators, was at variance with his poetry of frustration and escape. By pointing this out in an essay which made every Sanskritist who read it shudder, I had fallen into Indology, as it were, through the roof.

There was one defect in the essay, namely that the existence and the text of Bhartṛhari were both rather uncertain. This meant text-criticism, which ought to have been completed in a few months, as the entire work supposedly contains no more than 300 stanzas. Study of about 400 manuscripts showed numerous versions with characteristically different stanzas, as well as divergent readings in the common verses. It took two and a half years of steady collation work to realize that I should not have undertaken such a task; but abandoning it then would mean complete loss of the heavy labour, which could yield nothing to whoever came after me. It took some five years to edit Bhartṛhari, with results that have received professional approval. The methods did not apply when the oldest known anthology of classical Sanskrit verse, composed about 1100 A. D. under the Pāla dynasty, was edited (with a very able collaborator) from atrocious photographs of two manuscripts, one in Tibet, and the other — most corrupt — in Nepal. My judgment

of the class character of Sanskrit literature has not become less harsh, but I can at least claim to have rescued over fifty poets from the total oblivion to which lovers of Sanskrit had consigned them, not to speak of adding to our meagre knowledge of many others.

All this gave a certain grasp of Sanskrit, but hardly of ancient Indian history; the necessary documents simply did not exist. My countrymen eked out doubtful sources with a powerful imagination and what L. Renou has called 'logique imperturbable'. One reads of the revival of nationalism and Hinduism under Chandragupta II, of whom nothing is known with certainty. Indian nationalism is a phenomenon of the bourgeois age, not to be imagined before the development of provincial languages (long after the Guptas) under common markets. Our present-day clashes between linguistic groups are an index to the development of local bourgeoisies in the various states. Hinduism came into existence after the Mohammedan invasion. Clearly, one of two positions had to be taken. India has no history at all, or some better definition of history was needed. The latter I derived from the study of Karl Marx, who himself expressed the former view. History is the development in chronological order of successive changes in the means and relations of production. This definition will have to be abandoned for a better one if we cross the threshold to a radically new and better form of society. Then and only then will human history really begin, but till that time my definition will have to serve. We have, therefore, an Indian history without the episodes that fill the history books of other countries. But where were the relevant new sources? Granted that the plough is more important than a list of kings, when and where was it first introduced? What class took the surplus produced thereby? Archaeology provided some data, but I could get a great deal more from the peasants. Field work in philology and social anthropology had to be combined with archaeology in the field as distinguished from the site archaeology of a 'dig'. Our villagers, low-caste nomads and tribal minorities live at a more primitive stage than the city people or even than the brahmins who wrote the *purāṇas*. Their cults, when not masked by brahmin identification with Sanskritized deities, go back to pre-history, just as Romans at their sacrifices used stone axes and bronze knives. Tracing a local god through village tradition gives a priceless clue to ancient migrations, primitive tracks, early trade routes

and the merger of cattle-breeding tribesmen with food gatherers which led to firm agricultural settlement. The technique of observation has to be developed afresh for every province in India. The conclusions have had a mixed reception because of reference to Marx, which automatically classifies them as dangerous political agitation in the eyes of many. At the same time official Marxists look with suspicion upon the work of an outsider.

The method continues to give new and useful results. Experts say that my collection of microliths is unique, not only in range of sites but in containing the first known pierced specimens. A totally unsuspected megalithic culture came to light in this year's field work. It fell to my lot to discover, read and publish a Brāhmī inscription in plain sight at Karle caves, which had passed unnoticed though some 50,000 people visit the place every year. My suggestion for using Malshet pass should give Maharashtra a badly needed key road from Bombay to Ahmednagar, and save a few million rupees that would have been wasted by a projected, spectacular funicular railway down Naneghat.

5. Social aspects

The greatest obstacles to research in any backward, underdeveloped country are often those needlessly created by the scientist's or scholar's fellow citizens. Grit may be essential in some difficult investigation, but the paying commodity is soft soap. The meretricious ability to please the right people, a convincing pose, masterly charlatanism and a clever press agent are indispensable for success. The Byzantine emperor Nikephoros Phokas assured himself of ample notice from superficial observers, at someone else's expense, by setting up in his own name at a strategic site in the Roman Forum, a column stolen from some grandiose temple. Many of our eminent intellectuals have mastered this technique.

There is little point in discussing personal experience of the scum that naturally floats to the top in a stagnant class. The deep question is of fundamental relationship between the great discoverers and their social environment. Conservatives take history as the personal achievement of great men, especially the history of science. The Marxist assertion is that the great man is he who finds some way to fulfil a crying social need of his times. Thus, B. Hessen explained Newton's work in terms of the technical and economic necessities of his class, time and

place. The thesis was successful enough to be noticed and contested by a distinguished authority on 17th century European history, Sir George Clark. Clark's knowledge of the sources is unquestionably greater than Hessen's; but the refutation manages to overreach the argument. According to Clark, 'the scientific movement was set going' by 'six interpenetrating but independent impulses' from outside and 'some of its results percolated down into practice and were applied'. The external impulses were 'from economic life, from war, from medicine, from the arts, and from religion. What is left then of the independence of science? The sixth impulse was from the 'disinterested desire to know'. So far as I know, all six impulses applied from the very earliest civilisations of Mesopotamia, Egypt, China, and probably the Indus Valley, without producing what we recognize as 'science' from, say, the time of Galileo. What was the essentially different factor? The Marxist answer would be: 'the rise of the proto-bourgeoisie in Europe'. No Marxist would claim that science can be independent of the social system within which the scientist must function.

Much the same treatment may be given to literature. Disregarding oversimplification, can one say that Shakespeare's plays manifest the rise of the Elizabethan proto-bourgeoisie, when the said dramas are full of kings, lords and princes? The answer is yes. Compare Hamlet or Richard the Third with the leading characters in the *Chanson de Roland*. Not only Pistol, Nym and Bardolph but the fattest Shakespearean parts like Shylock and Falstaff are difficult to visualise in feudal literature. The characters in those plays have a 'modern' psychology, which accounts for their appeal to the succeeding bourgeoisie, and hence the survival value of the dramas themselves. Troilus and Cressida are not feudal characters any more than they are Homeric; Newton's Latin prose and archaic geometrical proofs in the *Principia* make that work unreadable, but do not make it Roman or Greek science.

Talking with Indian peasants gives a grim view of modern India, and of the service science can render to any society based upon the profit motive. The demoralisation of the poor and middle peasants (the vast majority) is explained by the miserable diet on which they have to subsist, year in and year out, generation after generation, with no hope of better. The passive, unresisting stratum thus created may provide the foundation for a dictatorship that could be evoked by the naked greed of kulak

and petty-bourgeois, the cynical grab of Big Money, facile opportunism of pliable intellectuals and the leaden foot of a bureaucracy never remarkable for honesty and efficiency. Surely, the problem of a better food supply is crucial, not only for attaining the socialism which is announced as India's goal, but even to preserve what democracy the country possesses. But what can the scientist do?

India, the experts tell us, is overpopulated and will remain poor unless birth control and population planning is introduced. But surely, overpopulation can only be with respect to the available food supply. Availability depends upon production, transport, and the system of distribution — here under private control. What is the total amount of food produced? We have theological quarrels between two schools of statisticians, but no reliable estimate of how much is actually grown, and what proportion thereof escapes vermin — including middlemen and profiteers — to reach the consumer. If shopkeepers can and do raise prices without effective control, what does a rise in the national income mean? Is it the scarcity of grain or of purchasing power? A great deal is said about superstitious common people who must be educated before birth control becomes effective. No superstition which runs strongly counter to their fundamental economic interests continues for long to grip the 'common people'. Children are the sole means of support for those among the common people who manage to reach helpless old age. The futility of numerical 'planning' for the population, when nothing is done to ensure that even the able-bodied will have a decent level of existence, is obvious to any one but a born expert. It is not that our poverty is due to overpopulation, but rather that the overpopulation is due to poverty. Convince the common people that they will be fed and looked after even when they have no children, and birth control will immediately become popular.

Let me give two small examples of scientific effort which could easily have been turned to better account. Considerable funds will be devoted during the Third Plan to research on the uses of bagasse (sugarcane pulp). At present, it is used as fuel, and the ashes as fertilizer, whereas paper and many other things could be made from it. But are the other uses (quite well known) the best in the present state of Indian economy? The extra money to be spent on fuel, not to speak of difficulties in getting fuel, would increase the already high cost of

sugar manufacture; new factories for byproducts mean considerable foreign exchange for the machinery, and for the 'experts'. But Hungarian scientists fermented the bagasse in closed vats. The gas given off can be burned, so that the fuel value is not reduced; the sludge makes excellent fertilizer for the fields, without any further treatment; this saves money on chemical fertilizers and improves the soil. The scheme has apparently been pushed into the background. Again: the proper height of a dam is important in order to reduce the outlay to a minimum, without the risk of running dry more than (say) once in twenty years. The problem is statistical, based upon the rainfall and runoff data where both exist. The principles I suggested were adopted by the Planning Commission, though not as emanating from me. Neither the engineers nor the Planning Commission would consider a more important suggestion, namely that many cheap small dams should be located by plan and built from local materials with local labour. Monsoon water would be conserved and two or three crops raised annually on good soil that now yields only one. The only country where I have seen innumerable small dams spring up during the last five years is China, which has not failed to construct giant dams wherever necessary. However, it is futile to speak — even from my personal observations in the field — of the exhilarating achievements, social and material, of the Chinese since liberation. Here, the obstacle is not ignorance, but private ownership and lack of co-operation.

This country needs every form of power available, but is too poor to throw money away on costly fads like atomic energy merely because they look modern. A really paying development will be of solar energy. The advanced countries have not so much sunlight as we do, hence care less for the development. The problem lies deeper than is imagined. The reforestation indispensable for good agriculture will not be possible without fuel to replace firewood and charcoal. Coal mining does not suffice even for industry, fuel oil has to be imported. An efficient solar cooker would be the answer. Such cookers exist and have been used abroad. The one produced in India was hopelessly inefficient (in spite of the many Indian physicists of international reputation). Tremendous publicity and a faked demonstration made the gullible public buy just enough useless 'cookers' for a quick profit to the manufacturer.

In one matter, it was necessary to speak out though it

meant considerable damage to finances, health and research. Atomic war and the testing of nuclear weapons must stop. A flimsy 'Indian Report' on the effects of atomic radiation shows our moral and scientific bankruptcy by ignoring the extensive data compiled since 1945 in the one country which has had the most painful experience of atomic radiation applied to human beings — Japan. The real danger is not death, which is a release for most Indians, but genetic damage to all humanity. We know what radiation does to heredity in the banana-fly *Drosophila melanogaster*, with its four chromosomes and life-cycle of eleven days. A good deal was found out in the USA about what happens to laboratory mice. What little has been released for publication is enough to terrify. Man is as much more complicated than a mouse as the mouse than the fruit-fly. Humans take a proportionately longer time to breed and to reach maturity, giving fuller scope for genetic derangements to develop. It may take some twenty generations to find out just what these derangements amount to. By then they will have been bred into many millions of human beings, not as a disease but incurably as a set of hereditary characters. Mankind cannot afford to gamble with its own future in this way, whether that future lies in the hands of communists or not.

Scientists had so far been, primarily, preoccupied with the discovery of new facts, and arranging them in some order, to have a better and deeper understanding of nature. They had, in their zeal for the new, overlooked the study of the nature and character of science, patterns of its growth, the trends of its development in different cultures and at different periods of history, and its interaction with other human activities. They had also given little attention to wider problems of science and its interaction with society. Two possible reasons, from amongst the many, appear to be significant; as they are historical and social in character, it might be worth mentioning them at some length.

Firstly, as Whitehead pointed out in his classical book — “Science and the modern world” — science developed as a revolt against excessive ratiocination of medieval philosophy and represented an assertion for primacy of observation and, brute facts over the facts deduced from theories. Consequently, many early scientists, Newton for instance, eschewed formulating hypothesis and theories. The idea being that as and when the secrets of the nature would be revealed, more facts would be made available, it would be possible to advocate theories which would be irrefutable. Further, as things stood then, it would not have been possible to establish new theories based on the meagre data and information — the latter, particularly in view of the overall outlook of the period and the weight of the philosophical authorities and religious dogma, and consequent political control. In other words, this approach was not an inherent part of science, but a part of its historical development, as a reaction to social and intellectual climate which then existed in the early stages of its growth.

Secondly, it was also believed in the early stages of science

that, as against the knowledge as was then available, the facts of science were irrefutable. Bacon, for instance, felt that science was a direct refutation of common prejudices and superstitions, which then went by the name of knowledge. As against this everything in science was securely founded, and once established could not be changed. Under the influence of these ideas the tasks of the scientists, it was felt, was to propagate the new discoveries and explain them to the people. It was believed that as this knowledge would permeate to people, slowly and gradually, through education, the old superstitions and prejudices would disappear and people would acquire the new scientific outlook and attitudes. This was the main motive force, I believe, behind the early great movements for popularization of science — through public lectures and debates.

Later developments in science, however, were to tell a different story.

While this conceptual outlook continued to dominate most of the scientists, with the increase in specific information about the natural phenomena and increase in the number of scientists, theories began to be formulated and the available knowledge began to be increasingly used for social purposes. The latter began to give shape to human dreams of a new society as well as raised serious moral and ethical questions. These dreams, questions, and the debates, in the nineteenth and early part of the twentieth century are interesting reading; and re-reading them now does indicate to us, that though at the time these questions appeared to be an intrinsic part of science, actually they were not and much more was involved than mere scientific conclusions. In fact, they were intrinsically a part of the level of development of science, national outlook and attitudes of the scientists, philosophical and cultural milieu of the different countries and societies and the social and political developments which were then taking place in Europe.

After the first world war and the events following, two problems came to surface and gave rise to two trends. Firstly, they raised the question of the misuse of science for purposes of war, i.e. destruction, and for purposes of profit at the expense of human good. In view of the channelling of the resources of science in these two directions, science could not be utilized for solving urgent problems of society. Secondly, there was the positive assertion, under the impact of Russian Revolution, of science as an instrument of social and intellectual transformation, and the

need for its use in this direction.

Considerable energy of the scientists in the thirties was directed towards the study and debate on these problems and the concept of social functions of science was developed. These ideas, as they were then generated, concerned themselves with the development of science and the impact it had on society, and numerous suggestions, at various levels, were thrown up to better organize and utilize science for well-defined social objectives. When contrasted with earlier role and attitudes, this particular period suggests that science had come of age; it could now speak with confidence and suggest a wide range of solutions for a number of problems, and begin talking as an active instrument of change, and even of controlling and directing this change on specific lines.

While this trend was gathering momentum, the second world war broke out. When it ended, man and human society came face to face with the senseless destruction, which had gone on for years, and the critical choice of survival or utter annihilation posed by the atomic warfare. Scientists became acutely aware, and many suffered a sense of guilt, as being an instrument of what had happened. They, therefore, started occupying themselves with the problems they themselves had created. When they started giving serious attention to these problems, a new understanding began to dawn on them viz. that many things have changed qualitatively, requiring a new approach and outlook.

It would be worthwhile to point out briefly these changes.

Character of Science

It may be emphasized that as a result of the accumulation of scientific knowledge over the centuries, science itself has undergone a major change. In the first stage of the evolution of science it gathered information about nature and threw up possibilities of new raw materials for use. The next stage was the utilization of these raw materials and as a result accumulation of new knowledge, which in turn led to modification of the raw materials to suit the specific needs. The third stage, in which we now find ourselves, is where man has begun to synthesise the raw materials, in order to meet the new demands. The synthesis of raw material marks a total change in the situation, in so far as man is no longer circumscribed by the materials available to him. He is now in a position to make any material of

required specification, as long as he knows what he wants and is prepared to invest the necessary resources to achieve the desired end. This brings to surface a major and new problem for the modern scientists — viz. choice of objectives. More of this later.

The Scientists

The position of scientists has also been vitally affected. From a lone worker, heroically pursuing his convictions he has been transformed into a scientific worker. The latter signifies that he is like any other worker, employed to do a specific job, and working for a defined salary and for fixed hours of the day. This has profoundly affected his outlook, attitudes and motivations. For instance, as Merton and Storer have pointed out, in their studies on Sociology of Science, the scientists no longer look to internal rewards of the scientific community itself, but search for wider recognition by society as a whole. Hence, money, prestige and power have come to occupy a greater role than mere professional recognition.

Secondly, the size of research projects has not only brought about a collaboration amongst a number of scientists in the same discipline or from amongst a number of different disciplines, but the size and character of a research team have introduced different concepts of cooperative work altogether. Further, the latter have also created a totally different type of research organization. Today a research project may be decided at an academic or academic-political level and a large number of scientists may be employed to achieve the objective, each group working in a limited field, as suggested or indicated by the decision-making group. Much of the heavy investment research — nuclear energy, aeronautics or space research — falls under such a category.

Organization of Science

The management problems which have come to the fore as a result of these changes are also significant. The organization of a research laboratory, as against the early research establishments in the universities or the Leibig type of research laboratories, has also undergone a major change, and has now a greater economic orientation.

Besides, the number and type of laboratories have also proliferated. There are, for instance, the university research laboratories acting as centres of excellence built up around eminent men, or independent institutes, like the Salk Institute, to provide

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a place of work for outstanding workers who would like to take a chance for break-through in new areas. There are also contract research establishments in the universities, industries, or as private institutes doing specific work either for the government or the industry. There are also government or industry-sponsored laboratories built around a single area of research or to discharge multipurpose functions. Finally, there are huge establishments for research in fields like the Atomic Energy, or the Space Research, which represent a totally new type of organization for science.

All these types of establishment have introduced a new dimension in organization of science as well as in science itself.

Investment in Research

There was a time when scientists were supported by men of means but now the various national governments are making a major investment in research, from which they are expecting many-sided returns — economic, social, political and in the field of defence. Consequently research is not only judged by the possibilities of technological results but also by economic, political and social standards and defence objectives.

Such an approach to research brings to fore two types of questions. Firstly choice of the area for investment, the choice of problems within the area and the size of investment. Secondly, questions such as to who is to make the final decision — scientists alone, or the economists or politicians? The overemphasis of investment in area of defence — weaponry, space research, nuclear energy, aeronautics etc. and the neglect of research investment in biology, social research and related areas have forced the scientists to consider the consequences of this imbalance in science as well as society. The debate is now going on in a big way at least in the advanced countries.

Integration of Science with Human Activities

As a result of these developments scientists as well as others have come to realise, what a wit aptly expressed, that science has become too important to be left to scientists alone. The purely scientific issues and results are no longer sufficient to decide the merits of a research project, or the question of research investment, but very often social, economic, political and moral issues have a greater sway on deciding whether an area of work has to be taken up or not.

Kennedy's man on the moon was a political decision rather than purely scientific. It aimed at establishing the supremacy of USA over USSR, in terms of the scientific leadership and consequent political advantages accruing from it. Many voices have been raised against it as this emphasis has led to bypassing of many interesting areas of scientific research, or the latter's application to the solution of many urgent and vital social problems. The whole series of protests against biological warfare research establishments have also seriously posed the moral issues involved as well as the problems of misuse and abuse of science.

Problems of Choice and Organization of Resources

These discussions and debates at various levels have again and again posed before the scientists, as well as the society at large, the question of choice — choice of objectives and goals, choice of means to react to them and the consequent creation and mobilisation of resources to achieve them. It does appear, from the available information and knowledge we possess and the means available at our disposal, that there is hardly any goal which is outside human reach. Every choice would mean the rejection and discarding of a number of possibilities and the consequent change in the direction of society. The road allows only one-way traffic, once the direction is chosen there is no going back.

How are we to affect the choice? How are we to weigh the various alternatives and the consequences of each? Have we the means to do so? Perhaps, faced as we are with these vital issues, the next step in science might be in this direction. Would that not mean a total change in our outlook and concepts, attitudes and practice? What does it mean to our society and its culture?

These questions have to be faced and an answer to them sought. Whatever be the detailed answer one thing is becoming increasingly apparent that nothing short of a pervasive social transformation would suffice. Our attitudes and habits have to change radically and we would have to re-orient our values totally if we have to face and solve these problems. In fact, we have to re-weave the fabric of our life.

Consequently, the main task of the scientists, apart from continuing with their discoveries, could be, in the context of the modern developments, to bring these issues to surface, establish communications with other groups and thus to help to give shape to future developments. The days of classical popularization of science have gone with classical science, and so have the days

of social relations of science with World War II. Science and society are now face to face with the second scientific revolution and post-industrial revolution; the problems of this phase are different and it is to these tasks to which the scientists have to address themselves, viz. to establish the new relations of science with society.

3 The Protein Problem

P. V. Sukhatme

1. Introduction

Protein more than any other constituent of food has been singled out for attention in recent years. The reason is that protein deficiency if allowed to develop in early childhood may leave adverse effect on health, body growth and possibly mental growth also, effects which are difficult to remove in later life. It is therefore important to know the size and nature of the protein problem. It will be the object of this paper to attempt such an appraisal with particular reference to Maharashtra.

2. The overall size and incidence of the protein gap

The estimate of the overall size of the protein gap is given by the difference between the per caput supply of total protein and the corresponding requirement and is set out in Table 1. The estimate of supply is based on food balance sheet data for 1963/65 and that of requirement is based on the latest recommendations (ICMR 1968). It will be seen that supply exceeds requirement. Unlike calories, there is thus no overall shortage of protein in the country. The supply in fact exceeds requirement by some 20%. The conclusion is that the average Indian diet, while inadequate in calories, has more than adequate protein to meet the physiological needs.

To be specific, an average Indian diet contains a little over 50 grams of dietary protein against a requirement of some 45 grams a day. And yet there is ample evidence to show that an appreciable part of the population do not get adequate protein to meet their physiological needs. This is best seen from Table 2. The Table relates to data for Maharashtra. It shows that as income improves, the supply of total protein in the diet also im-

proves. Further, the protein deficiency is seen to fall heavily on the poorest sections. Clearly, with the rich taking enough and more and the poor only what they can afford, proteins appear to be very unevenly distributed in the population.

The foregoing analysis suggests that an appreciable part of the population has a diet deficient in protein. It does not however make possible an estimate of this proportion. To assess the latter one must turn to the distribution of protein intake relative to requirement. Given such distribution $f\left(\frac{u}{v}\right)$ for intake u and requirement v we can express the incidence of protein deficiency thus

$$\int_{\frac{u}{v} < 1} f\left(\frac{u}{v}\right) d\left(\frac{u}{v}\right) \quad (1)$$

The evaluation of expression (1) however presents a difficulty, since there is almost complete lack of information on the frequency function. What are generally available are the protein intake distributions of households on a nutrition unit¹ (reference man) basis. Given such a distribution $g(\bar{u})$ it can be shown that expression (1) can be approximated by

$$\int g(\bar{u}) d(\bar{u}) \quad \dots \dots \dots (2)$$

the integral being taken over the range $\bar{u} < \mathcal{L}' - 3\sigma_{\bar{v}}$ where \mathcal{L}' is the requirement of protein of NPU = 100 of the reference man and $\sigma_{\bar{v}}$ is the standard error of households on a nutrition unit basis (Sukhatme, 1961). Ordinarily, in a well-fed population with no one protein deficient and assuming normal distribution, most households can be expected to have their protein intake per nutrition unit higher than the critical limit given by $\mathcal{L}' - 3\sigma_{\bar{v}}$, i.e., the average requirement of the reference man minus three times the standard error. It follows that in any observed distribution the proportion of households with protein intake per nutrition unit falling below $\mathcal{L}' - 3\sigma_{\bar{v}}$ may be taken to provide an estimate of the incidence of the protein gap in the population.²

1. The nutrition unit for protein represents the average requirement of the reference man, namely 30 grams of reference protein of NPU = 100.
2. The existence of protein deficiency in the diet of a household does not mean that the diet of every member of that household is deficient in protein. Food is not distributed in proportion to needs, especially

Table 3 gives the observed distribution of protein intake per nutrition unit in households of Maharashtra based on the data for the National Sample Survey collected in the course of the 14th Round during 1958. To estimate the critical limit it is known that the coefficient of variation of protein intake among healthy active individuals of the reference type is of the order of 10%. Assuming that households on average consist of four nutrition units, this implies a standard error of 1.5 grams per household per nutrition unit. Since the average requirement of the reference man is 30 grams of reference protein, it follows that the critical limit for assessing the proportion of households with inadequate protein intake can be placed at $30 - 3 \times 1.5$ or 25.5 grams. In view of the fact however that protein distribution is very skew it appears appropriate to place the cut-off point at two times the standard error instead of three, thereby giving the critical limit the value of 27 grams of reference protein at the physiological level or roughly 29-30 grams at the retail level. Table 3 shows that about $\frac{1}{4}$ of the total households from Maharashtra have a protein supply less than the critical value of 29 grams of reference protein. In other words, we may consider that $\frac{1}{4}$ of the people have a diet which is inadequate in protein. The respective values for urban and rural Maharashtra are 30% and 20% in round figures.

Table 4 gives the observed distribution of calorie intake per nutrition unit for calories based on the same households for which protein distribution has been given in Table 3. It has been shown elsewhere (Sukhatme, 1965) that the critical limit to estimate the incidence of calorie deficiency is 2300 calories at the retail level. It follows that about one-third of the people in Maharashtra are calorie deficient or undernourished.

It is interesting to note that the proportion of households with inadequate protein intake is less than the corresponding proportion with inadequate calorie intake. In other words, the incidence of protein deficiency appears to be smaller than the incidence of calorie deficiency in the population. Thus, whereas the incidence of calorie deficiency is about $\frac{1}{3}$, that for protein

in poor households. The same also holds, though to a smaller extent, for households with a protein supply above the critical limit. For want of information on individual intake it has been assumed that the two groups broadly come to balance each other and that in consequence the proportion of protein deficient households may be equated to the incidence of protein deficiency in the population.

deficiency is only $\frac{1}{4}$. It needs to be noted however that the incidence of protein deficiency in the population represents the proportion of persons with diets inadequate in protein intake and not the proportion of people who suffer from protein malnutrition, clinical and sub-clinical. We shall elaborate on this in the following section.

3. The incidence of protein malnutrition

In the analysis presented above, it has been assumed that the utilizable protein in the diet is independent of the calorie intake. The assumption is not valid. For when the diet is inadequate in quantity, as measured by its calorie content, the protein in the diet is partly diverted from its primary function to the provision of energy. The level of calorie intake below which this occurs can be derived from the work of Miller and Payne (1961). They have shown that on average a man will need a little over 6 calories for the synthesis of one calorie of protein. Since a reference man on average needs 1400 calories for basal metabolism it follows that the additional energy for anabolizing protein needed by the reference man will be roughly $120 \times 6.2 = 750$ calories. In other words, a reference man will need to have an amount of 2150 calories at the physiological level or the equivalent of approximately 2300 calories at the retail level in order that he may be able to utilize fully the protein in his diet. This minimum value is precisely the critical limit below which a man can be said to be calorie deficient.

It follows that the incidence of protein malnutrition cannot be equated with the incidence of protein deficiency in the population. To the latter we must add the proportion of those who, although taking adequate protein, do not take adequate calories in order to efficiently utilize the protein in their diet.

Given then a bivariate distribution $h(\bar{x}, \bar{u})$ for calorie and protein intake in households on a nutrition unit basis, we can express the incidence of protein malnutrition I formally thus,

$$I = \int_{\bar{u} < \bar{u}' - 2\sigma_u} \int_{\bar{x} < \bar{x}' - 3\sigma_x} h(\bar{x}, \bar{u}) d\bar{x} d\bar{u} + \int_{\bar{u} > \bar{u}' - 2\sigma_u} \int_{\bar{x} < \bar{x}' - 3\sigma_x} h(\bar{x}, \bar{u}) d\bar{x} d\bar{u} \quad (3)$$

where

$$g(\bar{u}) = \int_{\text{all } \bar{x}} h(\bar{x}, \bar{u}) d\bar{x}$$

and $X = \frac{X}{R/C} =$	calorie intake of a household per nutrition unit for calories.
$R =$	calorie needs of a household on the assumption that physical activity corresponds to that of the reference man.
$C =$	calorie requirement of the reference man.
$U = \frac{U}{R'/C'} =$	protein intake of a household per nutrition unit for protein of NPU = 100.
$R' =$	protein needs of a household in terms of protein of NPU = 100.
$C' =$	protein needs of the reference man in terms of protein of NPU = 100.
and σ_y, σ_v	represent standard errors of household on nutrition unit basis for calories and proteins respectively.

To evaluate expression (3) we need data in the form of bivariate distributions of calorie and protein intake on a nutrition unit basis. We have compiled such distributions for urban Maharashtra, rural Maharashtra and the State as a whole for households tabulated in Table 3 and 4. (Sukhatme, 1969.) Want of space precludes us from reproducing them all here. Instead we have reproduced only one distribution relating to the State as a whole. This is shown in Table 5.

In Table 6 we have summarized the results of these bivariate distributions for urban Maharashtra and rural Maharashtra and the State as a whole. The Table shows the contributions of the first and second terms of expression (3). It will be seen that there are some 10% of the total households which, although receiving adequate or more than adequate protein, are not able to meet their protein needs for lack of adequate total calories in the diet. Substituting from the Table in expression (3) we get for I

$$I = 26 + 10 = 36$$

We thus see that whereas the incidence of protein deficiency when based on protein intake alone is 26% it increases to 36% when the inter-relationship between protein and calories is taken into consideration. In other words, while about one quar-

ter of the households do not have adequate protein in their diet, that is, are protein deficient, the proportion of households which suffer from protein malnutrition is much larger and can be placed at a little over one-third. The respective values for the incidence of protein malnutrition in the urban and rural areas of the State of Maharashtra are

$$\begin{aligned} \text{I urban} &= 38 + 13 = 51 \\ \text{I rural} &= 21 + 8 = 29 \end{aligned}$$

4. Nature of the protein problem and its implications

More generally the incidence I of protein malnutrition can be expressed as the sum of three terms

$$I = A + B + E$$

corresponding to the three cells of the 2×2 diagram shown below where the dividing lines are placed at the critical limits for calories and proteins.

Protein Calories as % of total calories for
different cells of the 2×2 table.

	PD	NPD
CD	10.0 A	13.6 B
NCD	6.2 E	11.4 F

Term A comprises households whose diet is deficient in both calories and protein but which nevertheless has a protein calorie ratio of well over the 8% needed by the reference man taking his requirements of proteins and calories from a diet with protein which has an NPU of 55. It will be seen that over 60% of the protein malnourished households in the State belong to this cell. The percentage contribution of cell A to the total malnourished is twice as much for the urban as for the rural area. Clearly, the primary need of the households in this cell is to have an adequate quantity of food. To give more protein to households of this cell without ensuring that these proteins bring calories with them can hardly serve any purpose.

Term B comprises households whose diet is marked by a predominant calorie deficiency but which has no shortage of proteins as such. The protein calorie ratio for the diet represent-

ed by this term is 13%, which is much higher than the 8% needed to meet physiological needs. Nevertheless, these individuals also suffer from protein malnutrition because they are not able to synthesise all the proteins they get from their diet for lack of adequate calories. Table 6 shows that term B accounts for a little over one quarter of the protein malnourished households in the population. The pressing need of this group is clearly for more food and more calories and not more proteins.

Term E comprises households whose diet is predominantly deficient in protein but adequate or more than adequate in calories. This dietary pattern is characteristic of diets which have a staple food like cassava or sweet potato and is known to lead to kwashiorker. Unlike cells A and B whose contribution to the total malnourished is much larger, this cell is seen to account for only a small proportion of the total number of protein malnourished households in the State. In particular, its contribution is seen to be only about one-tenth of the total number of protein malnourished. The protein calorie ratio for the diet represented by this term is significantly smaller than needed by a man taking his requirements of proteins and calories. The pressing need of this group is clearly for more proteins irrespective of whether such proteins bring calories with them or not.

It follows that for the vast majority of children who are protein malnourished, protein malnutrition is the result of an inadequate quantity of food. The limiting factor as Gopalan puts it (1968) is the calorie supply and not proteins. This is best seen by combining terms A and B to represent a single term of calorie deficient individuals and expressing the incidence of protein malnutrition as the sum of calorie deficient and those who are calorie sufficient but who do not have adequate protein in their diet. Thus from Table 6 we have

$$I \text{ State} = 32 + 4 = 36$$

The corresponding values for urban and rural areas are given by

$$I \text{ urban} = 46 + 5 = 51$$

$$I \text{ rural} = 25 + 4 = 29$$

Clearly some 90% of the protein malnourished suffer from undernutrition, that is, are calorie deficient. The implication of this result is that proteins which cannot bring calories are unlikely to make any significant contribution to the solution of the protein problem in the country. It is for this reason among others that measures such as fortification of wheat with lysine cannot provide a solution to the protein problem in the country

unless the object of such fortification is to make a loaf into a weaning food which it is not and cannot be. Lysine is not even the limiting amino acid in the diet of the poor. In any case, fortification with lysine cannot improve the calorie content. Much the same remarks apply to petroleum proteins, but we shall not further elaborate on these measures since their discussion is outside the scope of the paper.

It remains to be shown that the protein calorie ratio for a man taking his physiological requirements of proteins and calories is met by a cereal/pulse based diet normally consumed by him. Table 7 shows values of the protein calorie ratio based on the latest recommendations for calorie and protein requirements (ICMR, 1968). The requirements for protein relate to dietary protein having an NPU of 55 which is in fact the npu of the average Indian diet. It will be seen that the protein calorie ratio for a man taking his exact requirement of protein and calories does not exceed 8% for any of the age groups except infants between six months and one year old for whom the protein calorie percent ratio is 9. The protein calorie ratio for children is actually smaller than for adults and even for toddlers it is not much higher than for adults. The widespread belief that diets for children must contain very much more concentrated protein than the diets given to adults is just not true.

Table 8 sets out the values of protein calorie ratio for different foods and their combinations. A comparison with Table 7 shows that even if the diet were to consist of wheat or rice alone it could meet man's needs for proteins. Wheat has a protein value adequate for all ages. The same is true of rice. However, no one lives on wheat or rice alone. The cereal is usually supplemented by pulses or vegetables, however small in amount. Even a loaf of bread is taken with tea with milk. Consequently, the protein value which is already adequate is further enhanced thereby more than meeting man's needs for protein. We conclude that man's needs for protein can be adequately met by the cereal/pulse based diet already taken in the country provided he takes enough of it to satisfy his calorie needs.

Infants will of course need special attention. In particular, it will be important to ensure a smooth transition from breast milk to solid diet. Weaning foods, provided they are cheap, may have a real contribution to make here in stretching the milk supply. In so far as the urban areas are concerned, there is already a heavy demand for milk and the dairy industry is

making notable progress. It will be important to ensure that this progress continues unhindered. Technology has a large part to play in this process by enabling the expansion of the available milk supply by toning and like measures. In so far as the rural areas are concerned, we must look to the cattle on the farm to provide the needed milk. The task is not easy but where this is the case, pulses suitably prepared, as for example *idli*, can well be used as a weaning food provided the quantity given to infants is not unduly high to start with. Further discussion is beyond the scope of the paper.

5. Summary

A little over one-third of the people of Maharashtra appear to be protein malnourished. Some 90% of the protein malnourished do not get enough food to eat, that is, are calorie deficient. Only some 10% have a diet which is predominantly deficient in protein and yet is adequate or more than adequate in total calories. Proteins which do not bring calories with them are therefore unlikely to make any significant contribution to the solution of the protein problem in the State. Since the problem of protein malnutrition is confined to infants and young children it will be important to ensure a smooth transition from breast milk to solid diet by providing infants with protein from animal sources like milk or suitable cereal/pulse based preparations, e.g., *idli* or other weaning foods, such as lactone. Once the transition is smoothly achieved the cereal/pulse based diets normally consumed by the people can meet man's needs for protein provided enough food is taken to satisfy his energy needs.

Table 1

Calorie and Protein Supplies per Caput (1963-65) and Corresponding Requirements Based on ICMR Recommendations 1968

	Calorie Supply	Calorie Requirement	Protein Supply g	Protein Requirement npu = 55 g	Protein Supply in terms of ref. Protein of npu 100 g	Reference Protein Requirement g
Physiological Level	—	2080	—	38.5	—	21.2
Retail Level	2050	2280	53.4	42.3	28.6	23.3

Table 2

Daily per Caput Calorie and Protein Supply by Expenditure Level, Maharashtra State, India 1958

Item	Monthly per caput expenditure in Rupees							Average
	0-8	8-11	11-13	13-18	18-24	24-34	34-	
Total calories	1,120	1,560	1,850	2,190	2,440	2,530	3,340*	2,100
Total proteins in grams	30.7	45.0	52.8	60.4	66.3	71.7	85.7	59.7
Number of households	76	114	87	82	102	83	349	893

* This value appears unduly high. It is stated that this is partly due to the exclusion from the household size of guests and labourers taking meals.

Table 3

Distribution of Households by Protein Intake per Nutrition Unit (in terms of Reference Protein—grams per day) Maharashtra

	Rural	Urban	Total
	% frequency	% frequency	% frequency
0 - 5	.3	2.6	1.0
5 - 10	1.4	.4	1.0
10 - 15	2.2	2.6	2.3
15 - 20	3.9	5.5	4.4
20 - 25	6.6	15.8	9.5
25 - 30	8.1	14.0	10.0
30 - 35	9.8	15.4	11.6
35 - 40	14.2	12.0	13.6
40 - 45	10.5	11.0	10.7
45 - 50	9.8	7.0	9.0
50 - 55	7.5	4.4	6.5
55 - 60	5.9	3.3	5.1
60 - 65	5.1	2.2	4.2
65 - 70	4.1	1.5	3.3
70 - 75	3.2	1.5	2.7
75 - 80	2.9	—	2.0
80 - 85	.9	—	.6
85 - 90	1.5	—	1.0
90 - 95	.3	—	.2
95 - 100	.5	.4	.5
100 and over	1.3	.4	.8
	100.0	100.0	100.0
	Rural	Urban	Total
N	590	272	862
\bar{X}	44.57	34.81	41.50
S.D.	19.6	15.2	18.6
C.V.	44%	44%	44%
% Incidence > 27	18%	33%	22%

Table 4

Distribution of Households by Calorie Intake per Nutrition Unit in Maharashtra

Calories	Rural	Urban	Total
	% frequency	% frequency	% frequency
< 900	2.2	2.9	2.4
900 - 1300	3.5	4.0	3.7
1300 - 1700	5.4	12.5	7.7
1700 - 2100	9.1	17.3	11.7
2100 - 2500	10.7	18.0	13.0
2500 - 2900	19.0	12.5	16.9
2900 - 3300	13.6	9.2	12.2
3300 - 3700	11.7	9.6	11.0
3700 - 4100	6.3	5.5	6.0
4100 - 4500	5.1	3.7	4.7
4500 - 4900	5.8)	2.2)	4.7
4900 - 5300	3.4)13.4	.4)4.8	2.4
> 5300	4.2)	2.2)	3.6
	100.0	100.0	100.0
	Rural	Urban	Total
N	590	272	862
\bar{X}	3040	2572	2892
S.D.	1138	1030	1124
C.V.	37%	40%	39%
% incidence < 2150 + 7% 2150	26.3	47.5	33.4

Table 5
Distribution of Households by Reference Protein and Calorie Intake at Retail Level, Maharashtra (1958)

Ref. protein intake per nutrition unit	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	75-80	80-85	85-90	90-95	95-100	100-105	Total %	
Calorie intake per nutrition unit/day	900	5	6	5	2	1	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	21	
900-1300	2	2	11	11	1	—	—	1	1	—	—	—	1	—	—	—	—	—	—	—	—	21	
1300-1700	—	—	—	3	18	34	9	—	1	—	—	—	—	—	—	—	—	—	—	—	—	32	
1700-2100	—	—	—	1	5	32	39	17	6	1	—	—	—	—	—	—	—	—	—	—	—	66	
2100-2500	—	—	—	—	2	10	15	39	35	8	2	—	—	—	—	—	—	—	—	—	—	101	
2500-2900	1	—	—	—	—	2	13	25	44	40	15	2	1	1	—	—	1	—	—	—	—	112	
2900-3300	—	—	—	—	—	1	5	12	14	17	33	14	7	2	—	—	—	—	—	—	—	146	
3300-3700	1	—	—	—	—	—	3	1	9	19	14	23	10	9	2	—	—	—	—	—	—	105	
3700-4100	—	1	—	—	—	—	—	1	2	2	3	8	3	14	7	5	4	1	—	—	—	95	
4100-4500	—	—	—	—	—	—	—	—	2	1	1	2	6	5	7	11	2	—	—	—	—	52	
4500	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	1	1	—	—	6.0	
Total	9	9	20	38	82	9.5	10.0	11.6	13.6	10.7	9.0	6.5	5.1	4.2	3.3	2.7	2.0	0.6	1.0	0.2	0.5	0.8	100.0
%	1.0	1.0	2.3	4.4	9.5	10.0	11.6	13.6	10.7	9.0	6.5	5.1	4.2	3.3	2.7	2.0	0.6	1.0	0.2	0.5	0.8	100.0	

Table 6

Per cent Incidence of Protein and Calorie Deficiency in Maharashtra

	Urban Maharashtra		% Sub Total	Rural Maharashtra		% Sub Total	All Households		% Sub Total
	PD	NPD		PD	NPD		PD	NPD	
CD	33	13	46	17	8	25	22	10	32
NCD	5	49	54	4	71	75	4	64	68
% Sub Total	38	62	100	21	79	100	26	74	100

CD = Calorie deficient
 NCD = Not Calorie deficient
 PD = Protein deficient
 NPD = Not Protein deficient

Table 7

Protein Requirements Expressed as Protein Calories per cent from a diet having an npu of 55

Age	Requirement of protein of npu 100/Kilo g	Requirement of calories/Kilo	NDP Cal %	% Calorie from Protein of npu = 55
½ - 1	1.4	110	5.1	9.2
1 - 3	0.73	100	2.9	5.3
4 - 6	0.69	83	3.3	6.0
7 - 9	0.66	80	3.3	6.0
10 - 12	0.62	68	3.7	6.6
13 - 15	0.59	59	4.0	7.3
16 - 19	0.54	57	3.7	6.9
20 - 30	0.54	50	4.3	7.9

Table 8

Per cent Calories Obtained from Proteins in Different Foods (mixtures providing 2800 Calories)

	A/T	A/T Revised	% Calorie from Protein	% Calorie from Proteins adjusted to npu = 55
Wheat	39	43	12.6	9.1
Wheat + pulse (12 : 1)	51	56	14.1	12.7
Rice	56	62	7.6	8.4
Rice + pulse (5 : 1)	60	66	9.0	10.2

Notes :

A/T represents the chemical score with amino-acid composition of egg as the reference pattern.

A/T revised, allows for underestimation of the chemical score based on Payne's relation between NPU standardized and the chemical score.

Figures in the last column are obtained by multiplying figures in columns (3) and (4) and dividing by 55.

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Denote by $f(x)$ the number of integers $n \leq x$ for which there is a simple group of order n . Dornhoff [2] proved that $f(x) = o(x)$ and Dornhoff and Spitznagel [3] proved that (c_1, c_2, \dots) denotes suitable positive absolute constants)

$$(1) \quad f(x) < c_1 x \left[\frac{\log \log \log x}{\log \log x} \right]^{\frac{1}{2}}.$$

Denote by $f_1(x)$ the number of integers $n < x$ for which there is a non-cyclic simple group. We are going to prove the following sharper result.

Theorem 1.

$$f_1(x) < \frac{x}{\exp \left(\left(\frac{1}{\sqrt{2}} + o(1) \right) (\log x \log \log x)^{\frac{1}{2}} \right)}$$

Denote by $P(u)$ the greatest prime factor of u . Let $u_1 < u_2 < \dots$ be the sequence of all integers which have a divisor $t_i | u_i$, $t_i > 1$, $t_i \equiv 1 \pmod{P(u_i)}$. Let $v_1 < v_2 < \dots$ be the sequence of all integers such that for every $p | v_i$ there is a divisor $t_i(p)$ of v_i satisfying $t_i(p) \equiv 1 \pmod{p}$, $t_i(p) > 1$. Clearly every v is a u . Thus $U(x) \geq V(x)$ ($U(x) = \sum_{u_i < x} 1$, $V(x) = \sum_{u_i < x} 1$).

It follows from classical results on non-cyclic simple groups that if there is a non-cyclic simple group of order n then n is

a v_i . For if $p^a | n$, $p^{a+1} \nmid n$ then the number of Sylow subgroups

$t(\alpha, p)$ of order p^α must be a divisor of n ; further $t(\alpha, p) \equiv 1 \pmod{p}$ and if the group is non-cyclic we must have $t(\alpha, p) > 1$.

Instead of Theorem 1 we prove $(f_1(x) \leq V(x) \leq U(x))$ and

$$(2) \quad U(x) < \frac{x}{\exp\left(\left(\frac{1}{\sqrt{2}} + o(1)\right)(\log x \log \log x)^{1/2}\right)}$$

Denote by $\psi(x, y)$ the number of integers not exceeding x all whose prime factors are $\leq y$. Put $y^z = x$ and assume $z < 4y^{1/2} \log y$. A theorem of de Bruijn then states that [1]

$$(3) \quad \psi(x, y) < c_2 x (\log x)^2 \exp(-z \log z - z \log \log z + c_3 z).$$

Now we are ready to prove (2). We split the integers $u_i < x$ into two classes. In the first class are the integers $u_i < x$ all whose prime factors are less than $\exp\left(\left(\frac{\log x \log \log x}{2}\right)^{1/2}\right) = I(x)$, and in the second class are other u 's. $U_i(x)$ ($i = 1, 2$) denotes the number of u 's not exceeding x of the i -th class. By (3) we have by a simple computation $\left(z = \left(\frac{2 \log x}{\log \log x}\right)^{1/2}, \log z = \left(\frac{1}{2} + o(1)\right) \log \log x\right)$

$$(4) \quad U_1(x) < \psi(x, I(x)) < x \exp\left(\left(-\frac{1}{\sqrt{2}} + o(1)\right)(\log x \log \log x)^{1/2}\right).$$

Now we estimate the number of u 's of the second class $U_2(x)$. We evidently have

$$(5) \quad U_2(x) \leq \sum_{p \geq I(x)} \sum_{t=1}^{\infty} \left[\frac{x}{p(tp+1)} \right] < \sum_{p \geq I(x)} \sum_{t=1}^x \frac{x}{p(tp+1)}$$

$$< x \sum_{p \geq I(x)} \sum_{t=1}^x \frac{1}{p^2} \frac{x}{t} < c_4 x \log x \sum_{p \geq I(x)} \frac{1}{p^2} < c_4 x \log x / I(x)$$

Now since $U(x) = U_1(x) + U_2(x)$, (4) and (5) implies (2) and this completes the proof of Theorem 1.

With a little more trouble we can prove

$$\text{Theorem 2. } U(x) = \frac{x}{\exp\left((1+o(1))(2 \log x \log \log x)^{1/2}\right)}.$$

We only outline the proof of Theorem 2. It is easy to see that

$$(6) \quad U(x) < \sum_p \sum'_{t} \psi\left(\frac{x}{p(tp+1)}, p\right)$$

where the dash indicates that the summation is extended over all integers $t \geq 1$ for which all prime factors of $tp + 1$ are less than or equal to p .

Using (3) we can deduce from (6) by a somewhat intricate computation that

$$(7) \quad f_1(x) < U(x) < \frac{x}{\exp\left((1+o(1))(2 \log x \log \log x)^{1/2}\right)}.$$

To prove the opposite inequality we first observe that

$$(8) \quad U(x) > (1+o(1)) \sum_p \sum'_{t} \psi\left(\frac{x}{p(tp+1)}, p\right)$$

The proof of (8) is somewhat cumbersome and we suppress it. De Bruijn [1] proved that the right side of (3) also gives a lower bound for $\psi(x, y)$ (for a different value of c_3). From this fact and from (8) a simple computation gives

$$(9) \quad U(x) > \frac{x}{\exp\left((1+o(1))(2 \log x \log \log x)^{1/2}\right)}.$$

Using (6) and (8) it perhaps should be possible to give an asymptotic formula for $U(x)$, but I have not succeeded in doing this.

I can prove that for $x > x_0$

$$(10) \quad f_1(x) \leq V(x) < \frac{x}{\exp\left(\left(\sqrt{2} + c_5\right)(\log x \log \log x)^{1/2}\right)}.$$

The proof of (10) is not quite simple and we suppress it. Further I can prove

$$(11) \quad V(x) > \frac{x}{\exp\left(c_6 (\log x)^{1/2} \log \log x\right)}.$$

I do not know which of these estimates is closer to the true order of $V(x)$.

It seems likely that $f_1(x) < x^{1-\epsilon_1}$ but (11) shows that the method used in this paper cannot be used to improve our estimate for $f_1(x)$ very much.

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Introduction

A look at the history of physics through the centuries shows that a physical theory can never be proved — it can only be disproved. Many well established theories had to be abandoned when it was realized that they could not explain fully the observed phenomena. In this sense Nature has always been one step ahead of man.

The observed phenomena can be classified into two categories — the controlled and the uncontrolled. The phenomena in the former category include experiments that can be performed in the laboratory. In such experiments it is often possible to vary different parameters in the environment, and thereby to test the predictions of a theory extensively. The phenomena in the second category do not permit such freedom of manoeuvre. Here man can only watch events as they occur in Nature, without being able to reproduce them in the laboratory. Such phenomena are found in astronomy. To obtain the maximum possible information from such phenomena requires a great deal of patience and ingenuity on the part of the observer. Also, the observed results do not have the same degree of accuracy that one expects from laboratory experiments.

For this fundamental difference, astronomy has stood apart from laboratory physics, although both have contributed and will contribute towards the progress of fundamental physics. A few centuries ago, laboratory physics was practically non-existent, and the theories of physics were tested on the astronomical observations. Since then the balance has swung in the opposite direction. While no dramatic progress was made in the astronomical techniques, the science of laboratory experimenta-

tion made rapid advances. Thus it was that while Newton's law of gravitation arose because of astronomical observations, the Maxwell equations, the theory of relativity, the quantum theory, all have been contributed by laboratory experiments.

Over the last two decades, however, observational astronomy has prospered remarkably. The use of new and big optical telescopes and the birth of radio astronomy have considerably widened the horizons of the observational astronomer. Moreover, recent techniques in cosmic rays, γ -rays and X-rays also promise to add to our information about the universe. It is therefore of interest to ask whether astronomy can again contribute towards the progress of fundamental physics.

We follow the discussion from two points of view. According to one point of view theoretical physics is guided by laboratory experiments alone, and the astronomical observations merely provide a wider framework in which to test the laws obtained in the laboratory. The second point of view is that we cannot talk of laboratory physics in isolation; and that the behaviour of the local system is influenced by the universe in a non-trivial manner. We shall consider the two points of view in that order.

From the Local to the Distant

Although with considerable ingenuity man has greatly widened the scope of the laboratory experiments, he is still limited by his environment. Thus he can test the behaviour of physical laws over a limited range of variables and then rely on an extrapolation of these laws to conditions outside the range of his experiments. This is where astronomy can make a valuable contribution. Because of the vast dimensions of space and time involved in the astronomical phenomena, we have an opportunity of testing the various laws of physics in situations that cannot be achieved in the laboratory. Below we shall discuss some of these situations and see how far the extrapolation from laboratory has been successful.

(i) *Motion of heavenly bodies* — As mentioned before, astronomy provided an excellent testing ground for Newton's laws of gravitation. The simple inverse square law

$$F = G \frac{m_1 m_2}{r^2} \quad (1)$$

which explains the drop of an apple, can also account for the motions of planets and satellites which so much puzzled the early Greek astronomers. Because of the weak nature of the gravitational interaction it has not been possible to test this law in the laboratory as extensively as for instance Coulomb's law could be tested. The big masses of astronomical objects generate appreciable gravitational forces. Indeed, gravitational force is the major known force considered in the motion of stars and galaxies.

Although the law given by (1) worked very well in astronomical dynamics, the first hint that all is not well came also from astronomical observations. Newton's law predicts that planets, moving under the attraction of the Sun, follow elliptical orbits. These orbits are slightly disturbed when the interaction between planets is taken into account. The paths of the planets as predicted by the theory can be compared with the observed data. A slight discrepancy was noticed in the case of planet Mercury. A rotation of some 42" per century of the perihelion of Mercury could not be accounted for. The discrepancy could, however, be explained by Einstein's general theory of relativity. In general the differences between the predictions of the two theories is so minute that laboratory experiments are difficult to devise to differentiate between them. The above example shows how astronomy can be useful under such circumstances. [There are two other astronomical tests which distinguish between Newton's and Einstein's theories. These are the bending of light by a massive object and the redshift of light waves travelling from strong to weak gravitational fields. But the actual observations are not accurate enough.]

(ii) *Stellar evolution and nucleosynthesis* — The structure and evolution of stars provides an excellent example of the difference between laboratory science and astronomy. In the laboratory gravitational force is weak while the nuclear force is strong. The two are, however, comparable in a star. In fact the question 'What keeps the Sun shining?' could not be answered until it was realized that the Sun obtains its energy by burning nuclear fuel.

In a simple model of the Sun, its equilibrium equations are

$$\frac{dp}{dr} = -\frac{GM(r)\rho}{r^2}, \quad \frac{dM(r)}{dr} = 4\pi r^2 \rho,$$

$$\begin{aligned}
p &= \frac{R}{\mu} \rho T + \frac{1}{3} a T^4, \\
\frac{4}{3} a T^3 \frac{dT}{dr} &= - \frac{K}{4\pi c} \cdot \frac{L(r)}{4\pi r^2} \rho, \\
\frac{dL(r)}{dr} &= 4\pi r^2 \rho \epsilon.
\end{aligned}
\tag{2}$$

The first equation denotes hydrostatic equilibrium between pressure and gravitation. The second relates mass to density while the third relates pressure to density and temperature. The fourth equation shows how the energy generated in the Sun is transferred from inside to outside, while the last equation relates the energy output to the nuclear energy source. The remarkable point about these equations is that they are the extrapolations of results obtained in the laboratory, and that their solution gives a very accurate description of the Sun!

This method has been applied to other stars to obtain the relations between their mass and luminosity and mass and radius. The results depend naturally on the chemical composition of the star. This changes as the star burns its nuclear fuel. Thus a star evolves with time, changing its luminosity and radius. Although the change in a given star during man's lifetime is very small, different stars in various evolutionary stages have been observed. The agreement between theory and observation is encouraging enough to justify the application of laboratory physics to astronomy.

By changing the nuclear species inside, the star acts as a thermonuclear reactor. The extreme conditions of temperature and pressure in the star have not yet been simulated in the laboratory. Stars in different stages of evolution provide us with information about the working of different thermonuclear reactions. The predictions of the theory can be tested by comparing the calculated abundances of different elements with the observed ones. The problem was first considered in detail by Burbidge, Burbidge, Fowler and Hoyle (1957).

(iii) *High energy astrophysics* — The high energy phenomena in astronomy provide even more extreme conditions than those found in the stars. Here the extrapolation of laboratory physics has not been so successful. For example, we are as yet not able to account for the energy reservoirs of strong radio sources. Synchrotron process gives the best explanation of this

type of radio emission. Using the synchrotron theory and the observed estimates of radiation flux, we can estimate the energy in the source in the form of magnetic field and the charged particles. Taking into account various efficiency factors, we arrive at a required reservoir in the region of 10^{62} erg. for a strong radio source. How is such a reservoir built up? Here we are in the same position that the astrophysicists were in, when they were trying to account for the energy generation in stars before the advent of nuclear physics.

The situation in respect of strong radio sources was made more dramatic by the discovery of quasi-stellar objects. These are highly compact, highly luminous (in radio or optical region or both) objects with usually large redshifts. If we interpret the redshifts as cosmological, these objects must be very distant. We then have to explain enormous reservoirs of energy (of the order of 10^8 solar masses) in very compact forms. Severe difficulties are encountered when we take into account the rapid fluctuation of energy output from these objects. In some cases the time scale is of the order of a few days. This sets an upper limit to the size of the object since we do not expect the disturbance to travel faster than light. Thus in some cases we may be dealing with objects of linear size 10^{16} - 10^{17} cms only! These difficulties have prompted some to suggest that these objects are not so distant. Their redshift could be due to Doppler effect if they were thrown out in an explosion or to the presence of strong gravitational fields. In the latter case, very large redshifts ($z \sim 2$ in some cases) point to the radius of the object being close to its Schwarzschild radius. Such a situation has not been encountered in other massive objects in astronomy, let alone in the laboratory. It would be interesting therefore to investigate whether general relativity remains valid under such extreme conditions.

Observations of cosmic rays, γ -rays and X-rays from astronomical objects provide information about elementary particle physics at high energies. Particles of energies far higher than those produced in the laboratory accelerators are observed in cosmic ray showers. Many of these observations have not been understood in terms of what is known in the laboratory. The problem of the origin of cosmic rays still remains a mystery.

(iv) *Cosmology* — The biggest extrapolation of laboratory physics was attempted when the general theory of relativity

was employed to construct models of the universe. Models considered by Friedmann (1924) and by Robertson (1935) and Walker (1935, 1936) assumed large scale homogeneity and isotropy. Under these assumptions the geometry of the universe is described by the line element

$$ds^2 = c^2 dt^2 - S^2(t) \left[\frac{dr^2}{1 - kr^2} + r^2 (d\theta^2 + \sin^2\theta d\phi^2) \right], \quad k=0, \pm 1, \quad (3)$$

where $r = \text{constant}$, $\theta = \text{constant}$, $\phi = \text{constant}$ denote the world line of a typical galaxy, and t is the cosmic time. The surfaces $t = \text{constant}$ are homogeneous and isotropic. $S(t)$ denotes a scale factor. The light from a distant galaxy is redshifted, a fact which can be interpreted in these models by saying that $S(t)$ increases with t . An increase of $S(t)$ with t is loosely described as the expansion of the universe.

These models were successful in accounting for Hubble's law for small redshifts:

$$Z = \frac{H}{c} D, \quad (4)$$

where Z is the redshift from a galaxy at distance D and H is Hubble's constant. The value of H could not be determined by Einstein's equations. It could, however, be related to the mean density of matter in the universe.

These models suffered from one drawback. They had a singular state at $S = 0$. Since this corresponds to a singularity of space time, all physical processes, as we know them, break down at this instant. Some interpret this moment as the moment of creation. According to them physics operates only from $S > 0$. Others assume that a way of avoiding this state would eventually be found — perhaps through a modification of physical laws at very high densities. Neither point of view can be regarded as satisfactory.

From the Distant to the Local

We now return to the second point of view mentioned in the introduction. To an experimental physicist working within the confines of his laboratory the idea that his experiments are influenced by the behaviour of the universe may seem ludicrous indeed. Below we shall consider certain developments in physics

which tend to suggest that the role of the universe in the behaviour of local phenomena may be non-trivial. Two of these developments came well before cosmology was established as a science.

(i) *The Olbers Paradox* — Why is the sky dark at night? This question was raised by Olbers in 1826. According to Olbers' calculations it appeared that the sky brightness should be enormously high — so high in fact that whether we were facing the Sun or not made no difference. This can be seen from the following simple argument.

In a static Euclidean universe with a uniform density n of bright objects, each of luminosity L , the flux of light received from objects located between distances R and $R + dR$ is,

$$4\pi R^2 dR \cdot n \cdot \frac{L}{4\pi R^2} = nLdR. \quad (5)$$

Thus the total flux from all bright objects in the universe would be infinite! A more careful calculation taking into account the finite size of each object gives a finite result. The sky brightness is then the same as that on the surface of each object. If a typical bright object is like the Sun, the sky brightness would correspond to a temperature of $\sim 6000^\circ\text{K}$!

This paradox — known as the Olbers paradox — was in fact raised long before Olbers by Halley (1720). A satisfactory resolution of the paradox had to wait until the concept of the expanding universe. In the models described in the last section, the flux received from an object of distance $R = rS(t)$ is not $L/4\pi R^2$ but,

$$\frac{L}{4\pi R^2(1+z)^2}. \quad (6)$$

Thus the redshift factor in the denominator cuts down the radiation from distant objects faster than the inverse square law, and is responsible for convergence. The sky brightness contributed by the universe then turns out to be very small and consistent with the observations.

The Olbers paradox clearly demonstrates how our local environment can be controlled by the universe.

(ii) *Mach's principle* — In the last century Mach put forward the controversial idea that inertia is not the intrinsic pro-

perty of matter, but is the effect of the background provided by the distant matter in the universe.

Mach was led to this concept through his criticism of Newton's laws of motion. Newton's second law of motion provides a quantitative expression for the inertia of matter—a concept which dates back to Galileo. This law is written in the form

$$P = mf \quad (7)$$

and states that the force P acting on a material body of mass m produces the acceleration f . The mass m measures the inertia of the body. The more 'inert' the body the greater is the force needed to provide a given acceleration.

In formulating the laws of motion Newton encountered the difficulty of a reference frame. Suppose (7) is true when the motion is measured relative to a reference frame S_0 . Then relative to a reference frame S_1 which has an acceleration a with reference to S_0 , the law would become

$$P - ma = mf_1 \quad (8)$$

where f_1 is the acceleration measured relative to S_1 . Thus extra terms appear in the law of motion, suggesting that S_0 has some special status. Newton postulated that such a special reference frame does indeed exist and called it the absolute space. All frames with $a = 0$, in uniform relative motion with respect to S_0 are called inertial frames. The frames like S_1 , with $a \neq 0$ are called non-inertial frames. These can always be detected through the presence of the extra term $-ma$ in the law of motion. This extra force being dependent on the inertia of the body, is called the inertial force. Newton describes the well known 'bucket experiment' in this connection.

Although S_0 was so postulated the mystery remained as to why such a special frame should exist at all. The mystery was heightened by another astronomical observation — that of measurement of Earth's rotation. This can be measured relative to S_0 by the Foucault pendulum. The value is the same as that measured relative to the background of the distant objects in the universe!

Mach argued that this observation has deep significance. It tells us that S_0 is determined by the background of the distant objects in the universe. Since S_0 is essential for the quantitative description of inertia through (7), Mach concluded that the concept of inertia is somehow connected with the background. If

there were no background there would be no inertia.

These ideas are designated by the name 'Mach's principle'. It is not our intention to go any deeper into this principle at present. Rather we would like to emphasize the difference between the Machian point of view and that discussed in the previous section. The concept of inertia and inertial frames plays a vital role in most laboratory experiments. In stating that these are determined by the behaviour of the universe at large distances Mach destroyed the purely local character of the laboratory. Because of this revolutionary outlook Mach's principle has remained a matter of controversy.

Although Mach's principle is about inertia, the concept that the universe interferes in local affairs is capable of generalization. Below we discuss a striking example of this concept in another branch of physics — the electromagnetic theory.

(iii) *The absorber theory of radiation* — There are two ways of describing the electromagnetic interaction between charged particles. In one the electric charges influence one another through the medium of the electromagnetic field, the influences travelling through the field at the speed of light. In the other, the charges interact directly with each other.

Although the concept of direct interaction between particles is historically the older of the two, it is not very popular. When first formulated, the concept was that of instantaneous interaction. This was contrary to the requirement of special relativity and led to conflict with experiments. It was subsequently reformulated to make interactions travel with the speed of light. Although this met the requirement of relativistic invariance, a new type of difficulty arose. The new formulation was time symmetric, and was in conflict with causality. Thus when we disturb a charge a we expect the field generated by a to travel into the future, i.e. to be described by the 'retarded' solution

$F_{\text{ret}}^{(a)}$. This formulation, however, gives the field generated by a as

$$\frac{1}{2} F_{\text{ret}}^{(a)} + \frac{1}{2} F_{\text{adv}}^{(a)}. \quad (9)$$

The presence of 'advanced' solutions appears to violate causality, although it is consistent with, and indeed required by Newton's third law of motion.

Advanced and retarded solutions also exist in field theory but the former can always be got rid of by a special choice of solutions. This choice is not available to the direct-particle-interaction theory.

This presented a stumbling block to any further development of the theory of direct interparticle action, until a breakthrough was achieved by Wheeler and Feynman (1945, 1949). They pointed out that although advanced interactions are present between particle pairs, they can be cancelled out altogether under certain circumstances. These are when the universe as a whole acts as a 'perfect absorber', i.e. it absorbs all electromagnetic disturbances generated by individual particles. In such a case the field* acting on particle a is given by

$$\sum_{b \neq a} \frac{1}{2} (F_{\text{adv}}^{(b)} + F_{\text{ret}}^{(b)}) = \sum_{b \neq a} F_{\text{ret}}^{(b)} + \frac{1}{2} [F_{\text{ret}}^{(a)} - F_{\text{adv}}^{(a)}]. \quad (10)$$

The right hand side shows that all particles $b \neq a$ act on a only through their retarded fields. The only advanced effect to survive is that in the second term. This denotes the radiative reaction on the particle. Although it appears to arise from the motion of a directly, it is in fact the outcome of the complete absorption by the universe. In the field theory the radiative damping is ascribed to self-action; in the present theory it is the response of the universe to the particle motion.

Wheeler and Feynman were able to show that the static Euclidean universe is a perfect absorber. Thus (10) would hold and no conflict with causality would be encountered. However, the universe is time-symmetric and the entire argument can be reversed to show that purely advanced fields also offer a self-consistent picture! In fact it is meaningless to distinguish between the two pictures in the absence of an independent arrow of time. Wheeler and Feynman recognised this and sought to relate the electrodynamic time-asymmetry to the thermodynamic arrow of time.

It was subsequently pointed out by Hogarth (1962) that the appeal to thermodynamics is unnecessary if one takes into account the expansion of the universe. An expanding universe is time-asymmetric and this removes the time-symmetry of the whole argument! Hogarth and later Hoyle and Narlikar (1963) were able to show that this is indeed the case for the well known

cosmological models. Thus the steady state model gives retarded solutions, but not advanced solutions, in a consistent way. The ever expanding Friedmann models give exactly the opposite result. This is because in the former the continuous creation of matter ensures that there is enough absorbing matter present along the future light cone. In the Friedmann models the matter density steadily decreases as the universe expands.

If we adopt the direct particle theory as a correct description of electromagnetism we have the following advantages. First, we are able to understand why retarded — not advanced — solutions operate in the laboratory. This is not a matter of choice (as in the field theory) but a requirement imposed by the universe. Thus, provided we live in the right type of universe, we can establish a direct connection between the electrodynamic and cosmological arrows of time. Second, this theory is free from the concept of self action and the associated infinities that beset the classical field theory.

There has so far been one respect, however, in which field theory could claim superiority. This was in relation to quantum theory. Field theory has been quantized and the resulting subject of quantum electrodynamics can claim several successes. Until recently there was no quantum electrodynamics of direct interparticle action. Recent work (Hoyle and Narlikar 1968) has shown, however, that the field theory can no longer claim this superiority. We conclude this section with a brief description of this work.

(iv) *Quantum electrodynamics* — A survey of problems in quantum electrodynamics shows that there are two types of problems in which the theory of direct interparticle action is likely to run into difficulties. These are problems of the vacuum and the problems associated with self action.

The former type of problems arise in quantization of electromagnetic fields. In the usual theory the fields are independent entities, and can be quantized. In this case the state of vacuum — i.e. with no fields present — has non-trivial properties. These properties play an important part in explaining diverse phenomena such as the spontaneous transitions of atoms, line widths, resonance fluorescence, etc. In the direct particle theories fields have no independent existence and therefore we cannot follow the same procedure. How then do we explain the above phenomena?

* The word 'field' in this theory means the 'direct particle field', i.e. the field generated by specified particles.

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The problems connected with self action lead to difficulties in classical field theory. These difficulties are present also in the quantum field theory. However, ingenious renormalization procedures are devised to extract finite answers from apparently divergent expressions. That these finite answers are in excellent agreement with experiments (e.g. in the case of the Lamb shift in a hydrogen atom) is claimed to justify the somewhat non-rigorous nature of the renormalization programme. It is also regarded as an evidence of the action of an electric charge on itself. Can such experiments be explained in the direct particle theory which denies self action?

It is not possible to go into the details of the recent work which shows how these difficulties can be surmounted. The clue lies in the second term of the right hand side of (10) which denotes the response of the universe. A similar 'response' term exists in the quantum calculations and is able to account for the various phenomena described above. For this it is essential that the universe acts as a perfect absorber along the future light cone.

Conclusion

Having considered the two points of view in the two previous sections it seems that both are essential for the progress of physics. There is no doubt that astronomy has gained a lot from laboratory physics. The use of astronomy, on the other hand, provides laboratory physics with a valuable extension of its horizons. The laws tested in the confines of man-made walls can be tested in vastly different surroundings. At the same time it appears wrong to ignore the influence of the universe on local environment altogether — as shown by the Olbers paradox. To what extent the universe influences the local conditions is a matter of controversy at present. If the global outlook proves to be successful in our understanding of the laws of Nature — as seems in the case of electrodynamics — the theoretical physicist may well have to widen his outlook considerably.

Some Notions of Space, Time, Mass and Motion

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1. *Preamble*: It has been maintained by Bertrand Russell¹ among others that the language of daily life, with words used in their ordinary meanings, is inadequate for philosophy and surely therefore for physics. A technical language like symbolic logic is considered necessary to make inquiry worthwhile. But any technical language must ultimately rest on definitions of at least some terms. Here we reach another stone wall. As Russell² himself told us, years ago, since all terms are defined by means of other terms human knowledge must be content to accept some terms as intelligible, without definitions. This state of knowledge should have a petrifying effect on thought, since the foundation of it all is supposed to rest on faith in the meaning of a few terms; nor can we be sure in advance whether the rules for manipulation of accepted terms are valid. Moreover, any symbolic language in use today can satisfy human desire for communication only to a limited extent. It is not yet developed enough even to handle mathematics. No doubt, a re-formation of the languages and the alphabets is an urgent requirement. But the new languages will have to fulfil not only the exact needs of science but also the exotic requirements of other cultures and variegated human sensibilities. The only way out for me at present appears to be a return to the language of common usage. This essay, then, is by no means a deductive piece of work. It will use the common language of physics and proceed in a rather discursive and historical manner.

2. *Basic Categories of Physics*: The main element in human experience is change and no change seems possible without

motion. Russel³ considers that the concept of motion is *logically* subsequent to that of occupying a place at a time, and also that of change. But according to the present *physical* ideas it is impossible to envisage change without some accompanying and simultaneous change in the motions or propagation of some elements of the changing entity. Thus a hot piece of iron changes "colours" as its thermal motions diminish.

Motion itself involves the notion of matter or mass (and by abstraction also of an accompanying field) which moves, and of location in space and of the passage of time. These three — mass, space and time — are the basic categories of physics which cannot be reduced to more primitive ideas. (We leave electricity and magnetism out of account here. The word field refers to a gravitational field.) Other entities in physics can be derived by mathematical manipulation of these three. What limits the creation of these other entities? And, one may also ask the naive question: do these derived entities "really exist"?

The history of physics shows that creation of new entities is a continuous process. Velocity, acceleration, momentum, energy, event, space-time interval, action, spin, parity, strangeness, etc., were posited to give explanations of observations and to formulate laws, which could be simply expressed in terms of these entities. These explanations often take the shape of a principle of conservation or invariance of some physical quantity. Thus the relative velocity of a mass is conserved unless a force is operating on the mass. The angular and linear momenta are likewise separately conserved. The space-time interval between two events is an invariant for all inertial observers. An impression is then soon created that these physical quantities "really exist". But we have no direct perception of even linear velocity although the eye can quantitatively perceive angular velocity. A mass can be localized, for instance, in the palm of the hand but it is not at all easy to say where energy is located. A lot of trouble could be saved if we abjured the desire to localize physical quantities or to reify them as Bridgman⁴ put it. We should learn to recognize them rather abstractly by their correspondence to some observations or calculations. This attitude is necessary even in the case of the three basic entities of physics — mass, length and time — which according to the theory of relativity are not invariant but seem to change with the state of motion of the observer. A mass in motion is observed to be more.

If we then regard mass as quantity of matter, this would mean that motion creates matter. This sounds absurd.

3. *Definition of Motion*: Our previous observations make it necessary to introduce the concept of a frame of reference in which physical quantities are measured. The measures in different frames of reference may be different. Relative to a frame of reference, the state of a mass or a particle may be given in terms of what Feynman⁵ calls, where and when, or location and time. Motion then depends on the relationship between location (x) and time (t) of the type $x = f(t)$, relative to a given frame of reference. The quantities x and t can be understood in terms of crude perception but the notion of velocity $\left(\frac{dx}{dt}\right)$ and acceleration $\left(\frac{d^2x}{dt^2}\right)$ was assimilated over the centuries only with difficulty. The Greek Parmenides thought that change or movement could not be understood rationally. He argued that either a thing cannot change or the change is only apparent, because if a thing changes, then it is no longer the same thing and if it does not, change is only apparent. His pupil Zeno similarly argued that an arrow in flight is at any moment equal to itself, in a definite position, and therefore at rest; hence the flying arrow is at rest wherever it is throughout its flight. The possibility that an arrow can have a definite position at a given moment, i.e., have a given x at a given t , and yet have velocity or $\frac{dx}{dt}$ different from zero, is obviously not admitted by Zeno. Many of us will find on reflection that as students we too had some difficulty in grasping the notion of a differential coefficient $\frac{dx}{dt}$ at a point (t, x) .

Aristotle⁶ thought that the natural motion of heavenly bodies was circular but of earthly objects rectilinear. He also believed that heavier bodies fall faster towards the earth. Even Galileo⁷ thought that a heavenly body would forever move in a circular path. However, Galileo was one of the first to question Aristotle and to proclaim that a cannon ball or a musket ball both fall towards the earth with the same acceleration, and after some early errors finally gave the correct equation of motion of a falling body in the well-known form, $x = \frac{1}{2}gt^2$.

4. *Space, Time and Matter*: Buried deep in the heart of physics are the notions of space, time and matter, but we seem to be as far from understanding the nature of these as the ancients were. Thus we do not seem to be much farther than Locke who defined matter as "a something I know not what".

The ancient Indian sages had also speculated on these subjects and it is refreshing to see how "modern" some of their ideas were. According to the Jaina philosophy⁸, time which is formless is incapable of motion; that is to say, it cannot be manipulated: the function of time is to explain existence in the present, change, motion and duration. The theory of relativity, however, shows that time can be manipulated: for example, a clock or a biological process is slowed down when placed in a gravitational field. But there still remains the possibility that this is a local effect and that there exists a cosmic imperturbable time, which some current theories of cosmology postulate. The Nyāya school⁹ recognizes the difficulty of the notion of "time present" which is regarded as a section separating the past and the future; it is not possible to separate the past from the future without the third notion of the present. This is reminiscent of Dedekind's definition of a real number as a section or a cut. According to the Vaiśeṣika¹⁰, the name time is applicable to a cause. Kant also regarded time as the main element in causation. Similarly, the Vaiśeṣika¹¹ says that space is the cause of the notions of east, west, etc., for one material object considered with reference to another material object (relativity of space). Akāśa (ether or field), time, space, atoms, self and mind are regarded as eternal substrata without lower species¹².

Those who consider these reflections of the Indians as trite may contemplate some more modern definitions like, "A duration is a temporal slab of nature" by Whitehead¹³, or "Time is what happens when nothing else happens" attempted by Feynman¹⁴. According to Bridgman¹⁵, the concept of time is determined by the operations by which it is measured. But the operations for measuring time may be altogether different; say a pendulum or light rays reflected between two mirrors may be used to record time, and yet these measurements may be concordant for a reason unknown. The notion of time is obviously more basic than the operations used in its measurement.

5. *Newton's Predecessors and Contemporaries*: It took a long time before speculations on the nature of space, time and matter, advanced understanding of motion and dynamics. Galileo (1564-1642) was the first to introduce the notion of acceleration and *experimentally demonstrated* the principle of inertia, viz., that the velocity of a body is not changed until it is acted upon by forces. As we saw earlier, the idea of even velocity was logically a puzzle to the Greeks. It is strange that although Galileo was in correspondence with Kepler (1571-1630), the former did not apparently know Kepler's laws of planetary motion¹⁶. It is fascinating to speculate upon the consequences which would have resulted if Galileo and Kepler had worked together, as they actually did in the mind of Newton (1642-1727). Kepler's laws for the motions of the planets about the sun are not true dynamical laws but "phenomenological" laws to the effect that, (i) the orbits are elliptical, (ii) the radius vector describes equal areas in equal times, and (iii) the period of revolution depends on the mean distance. The laws generalize the motions of planets but not of all bodies, as Newton's laws of motion and gravitation do. Descartes¹⁷ (1596-1650) recognized that velocity is an "intensive" but not an "extensive" or "geometrical" entity and that location and motion are always only relative measures. Descartes was also the first to formulate the law of inertia, the first law of motion¹⁸. Huygens (1629-1695) lectured at the Royal Society in London on the impact of elastic bodies as an excellent demonstration of the principle of conservation of momentum. He¹⁹ enunciated the theorem regarding centripetal force required for maintaining circular motion and seems to have believed firmly in the relativity of all motion.²⁰ Leibnitz²¹ (1646-1716), however, thought that the law of conservation of energy is fundamental and not of momentum as Descartes assumed. With the discovery that mass and energy are convertible, Descartes has proved to be more right although not long ago a contrary opinion was expressed by Cajori²² who was inclined to support those who considered kinetic energy as the more "objective reality". In fact according to the special theory of relativity, it is the combined energy-momentum tensor which is invariant for all inertial systems. Leibnitz²³ stated the principle of relativity of space, time and motion at length and clearly, but with some occasional uncertainty.

6. *Newton and his Laws*: The estimates of Newton's contribution have varied. He was the first scientist ever to be knighted in England. However, Coleridge²⁴ in a letter to Poole wrote that he believed that the souls of five hundred Newtons would go to the making up of a Shakespeare or a Milton. But it is well-known, Coleridge regarded science to be an antithesis to poetry. It might also be said in extenuation that the full discovery of the scientist's soul is of recent occurrence!

It is true that what Newton said on motion and gravity was mostly in the air during his time. While Mach thought that the statement of the third law was the most important achievement of Newton in so far as the laws of motion go, Jammer²⁵ has pointed out that Kepler had already a clear conception of the reciprocity of forces. Newton himself credited Galileo and Huygens for the first two laws. But, to use a phrase from modern communication theory, the ratio of signal to noise reaching Newton, was so low that the process of rejection of ideas could not have been a simple one. One might almost say that Newton was already "tuned" to the laws of motion.

The point we want to examine in this essay is whether the three laws are really independent or they can be stated as a single law. In particular we shall consider the possibility that the third law contains the first and the second implicitly. Translated into English²⁶ the laws are :

- I. Every body continues in its state of rest, or of uniform motion in a right line unless it is compelled to change the state by force impressed upon it.
- II. The change of motion is proportional to the motive force impressed, and is made in the direction of the right line in which that force is impressed.
- III. To every action there is always opposed an equal reaction, or the mutual action of two bodies upon each other are always equal and directed to contrary parts.

These laws hold good in an inertial frame of reference. We discuss this point further later.

There are three leading ideas : there is no change in motion without force, change of motion or acceleration is due to force, and action and reaction are equal and opposed. The words "im-

pressed force", "motive force" and "action" apparently mean the same physical entity.

Although the second part of the third law seems to suggest that the case when there is no relative motion between two bodies, is under consideration, Newton makes it clear in the sequel that he means the more general dynamic case. He quotes the instance of a horse drawing a stone tied to a rope²⁷. The third law for a static situation is a trifling tautology. But for a dynamic situation it immediately leads to the question: if action and reaction are equal and opposed, how does any change of motion take place? Why does the stone move at all? This question troubles almost every student. Clearly we need a further analysis of the term reaction. The reaction must include the mutual actions of bodies in contact *as well as the inertial reaction*. In the case of the stone drawn by a horse, the action on the stone consists of the pull or force transmitted through the rope and the gravitational force on the stone (its weight). The reaction as ordinarily understood comprises the upward reactive force and the tangential frictional force at the surface of contact. But action and reaction so defined do not balance, i.e. the two are not equal and opposed, if the stone is accelerated. We must include the inertial reactions as well so that, on the whole, there exists a reaction equal and opposed to the action. These ideas have a pedagogic, heuristic as well as logical significance and are in a sense a statement of what is known as d'Alembert's principle^{28, 29}.

It might be said that to put down the expression for the inertial force $\left(-m \frac{d^2x}{dt^2}\right)$, we require the statement of the second law. The situation is as follows. The second law does not talk of inertial forces at all, but of impressed forces causing acceleration. The concept of the inertial force, which is reactive, arises out of the third law. This is made clear by Definitions III and IV preceding the enunciation of the laws in which Newton defines and explains "vis insita" or "innate force of matter" or the inertial force³⁰. The reactive force comes into play when there is change of motion and is proportional to it. The negative sign of the expression for the inertial force should be noted.

The postulational scheme may then be delineated as follows.

We are given the notions of: motion $\left(\frac{dx}{dt}\right)$; change of motion

with time $\left(\frac{d^2x}{dt^2}\right)$; impressed force or action (no matter what the origin of the forces, i.e. whether mechanical, gravitational, electric or magnetic); inertial force as a reaction to change of motion $\left(-m \frac{d^2x}{dt^2}\right)$; and passive reaction at the surfaces of contact when more bodies than one are involved. We then postulate the single law: Action and reaction are equal and opposed. We saw this law applied to the general case of a body subjected to impressed forces, reactive forces and acceleration. There may be no acceleration, and the impressed forces and the passive reactions may just balance, this is a special (static) case of the third law. Applied to, say, a single body subject to an impressed force, the law says that this force is equal and opposed to the inertial reaction $\left(-m \frac{d^2x}{dt^2}\right)$; this is a statement equivalent to the second law. When there is no impressed force and the inertial and reactive forces are also zero, there is no change in motion; this is the usual statement of the first law. The third law is the most general statement and includes the second law as a special case corresponding to the situation when a body is subjected to impressed forces and the only reactive force is inertial. The third law also includes the first law which corresponds to the idealized limiting case when there is no impressed force, reactive force or change of motion.

The concept of force is at the heart of the laws of motion and after stating the laws of motion, Newton therefore turned to the laws of forces determining motions of bodies on the earth and of planets in the solar system. Kepler had speculated on the nature of these forces, expounded that 'the mutual affection' of bodies is due to gravity which he compared to magnetism, and asserted that any two masses will unite due to attraction, in the process travelling distances in the inverse ratio of their masses³¹. Newton's contemporary Halley applying Kepler's third law, discovered the law that the attraction between the planets varies inversely as the square of the distance between them. Indeed, Ismael Bullialdus³² had held much earlier (1645) that the mutual attraction of the planets was according to the inverse square law. It is also likely that Newton was aware of Bullialdus's work³³. However, it was Newton who worked out the locus of a planet under an inverse square law of attraction. Moreover he put the law to a test in the motion of the moon and pertur-

bations to planetary motions. He established that on account of perturbations from various other planets, the orbit of any planet is not an exact ellipse as Kepler believed. He was thus the first to interrogate nature — to use Whittaker's phrase — on the subject of gravity. Newton was also the first to show that a spherical mass with homogeneous concentric layers could be considered as concentrated at a point in so far as the gravitational effects of it were concerned. This is believed to have delayed publication of Newton's idea by twenty years but was the most important step in calculation and verification of the effects of gravitation.

The celestial, lunar and terrestrial phenomena were thus all yoked together in one doctrine. Newton then struck out in all directions. He calculated the masses of the Sun and of the planets which have satellites, worked out the flattening at the poles of the earth and the consequent precessional motion of the earth's axis (in the case of a spheroid the gravitational pull does not act as if the mass was concentrated at the centre), discussed consequent variations in the gravitational field on the surface of the earth, worked out the irregularities in the motion of the moon, and laid the basis for a theory of tides. Newton's *Principia* written in the style of Euclid's *Elements* was thus one grand theme.

Bochner³⁴ has made an interesting analysis to show that it took more than 100 years to carry forward many leading ideas from the stage at which Newton left them.

How does the force of gravitation act? It has been said that Newton postulated gravitational action at a distance. As Cajori³⁵ has pointed out, this is not correct. I have never quite understood much that has been written on action-at-a-distance. The gravity field coexists with the masses (and its equivalent, energy). The question of propagation of the field arises when the masses are in motion and this problem is not yet fully understood³⁶. It does not even seem necessary that the masses be accelerated for the gravitational field to be disturbed; uniform motion should also result in gravitational propagation of some kind.

There are difficulties too with similar ideas connected with Newtonian motion. How does transfer of momentum take place to conserve the total momentum from instant to instant as observed in a given system of reference? When a boy spins a top, the angular momentum of the earth changes. Likewise when a

soldier fires a gun, the linear momentum of the earth changes. Apparently there is continuous transfer of momentum between the masses of the solar system; indeed the masses of the whole universe seem to be involved in the change of momentum of any single body, no matter how small. Can momentum propagate in space as a momentum field? This question drives one to question the very concept of mass as something confined to here-and-now. In these connections one may recall a penetrating remark of Thomas Carlyle, "You say that a body cannot act where it is not. With all my heart; but, pray, where is it?" As Mach put it, it seems impossible to disregard the rest of the universe, even when dealing with the mutual action of just two particles³⁷.

Notwithstanding these obstinate difficulties Newtonian dynamics proceeded from one glory to another in the hands of Euler, Lagrange, Laplace, Poincaré and others. So sure was Laplace of the awesome accuracy of Newtonian mechanics that when questioned by Napoleon as to why he did not mention the Creator even once in his *Celestial Mechanics*, Laplace replied that he did not need this "hypothesis". In the recent orbiting of the moon by the Russians and Americans, all calculations were based strictly on Newton's laws of motion and gravity.

There have been criticisms recently of Newton the man — even of Galileo. Aldous Huxley thought that Newton was a failure as a man, although he was superb as a monster (that is intellectually!) Rummaging in forgotten papers of Newton, prying J. M. Keynes³⁸ found Newton so much preoccupied with alchemy that he thought Newton was not the first of the age of reason but the last of magicians. It is now established that the findings of the Royal Society pronouncing priority of Newton over Leibnitz in the discovery of calculus, were sedulously drafted by Newton himself³⁹. It has been said that Galileo showed lack of courage when he abjured before the Inquisition for his belief that the earth has a diurnal motion of rotation. But scientists are neither saints nor martyrs by profession, and in every age they have carried their share of the contemporary load of subjugation and superstition.

7. *Between Newton and Einstein*: What is the main objective element in discovery or in the advancement of science? As E. A.

Milne put it, this is undoubtedly "logical pressure". Polanyi's "passionate element" is perhaps the most potent *subjective* element. Notwithstanding the fantastic success of Newton's laws of motion and gravity, some minor deviations, particularly the secular advance of the perihelion of Mercury, came to notice in the second half of the 19th century. Poincaré⁴⁰ tried to explain this on the basis of the special theory of relativity but he could thus account only for a fraction of the advance deduced from observation and theory. During this period the basic concepts of these laws also became the subject of detailed analysis. These "logical pressures" continue to operate and it is instructive to see how far they have carried physics towards a better understanding of motion and gravity.

As we stated earlier, the laws of motion hold for inertial systems (IS) of reference. IS are usually defined as reference systems of space and time coordinates in which force-free masses are observed not to be accelerated. As Einstein⁴¹ pointed out, this approach implies circularity. "A mass moves without acceleration if it is sufficiently far removed from other bodies; we know that it is sufficiently far removed from other bodies only by the fact that it moves without acceleration". It appears that IS can consistently be defined as "..... systems of reference which are in rectilinear and uniform motion relative to the aggregate of fixed stars"⁴². Clemence⁴³ has shown that IS can be tied to the system of the fixed stars (external galaxies). According to Russell⁴⁴ reference to the fixed stars savours of astrology, but this cannot now be helped. IS in uniform rectilinear motion relative to the fixed stars may be equivalent from the point of view of the laws of motion but are they also equivalent for the description of other laws of physics? This is the subject of the special theory of relativity; so also is the physical nature of space and time a subject of this theory. We shall return to these topics in subsequent paragraphs.

Even before the development of the theory of relativity, the notions of mass and force were put to a critical analysis. Newton's dynamics already implied that mass as "quantity of matter" played two different parts. One of these was the active role causing gravitational attraction and force; and the other was the passive role of inertia when subjected to force, whether of gravitational origin or of any other, say, electrical. Jammer⁴⁵ has further divided the first role into two, that of active gravitational mass which *induces* gravitation and secondly that of

passive gravitational mass which is susceptible and *responds* to gravitation. In other words m_1 and m_1' or m_2 and m_2' or F and F' in the force equations, $F = \frac{Gm_1 m_2'}{r^2}$ and $F' = \frac{Gm_1' m_2}{r^2}$, could be basically different physical entities. However m_1' is proportional to m_1 because Newton's third law holds, i.e. because $F = F'$ for all values of the m 's.

Now, experiments conducted by Newton himself, Bessel, Eötvös, Southern, Zeeman and Dicke have shown that the gravitational and inertial masses are proportional (not equal; this can never be said, so long as the two are regarded as different properties of matter), for all substances and situations. The general theory of relativity recognizes this equivalence approvingly, but as far as I know Einstein did not use or explain this fact at all. Its value to him was inspirational. Later Jammer⁴⁶ deduced this equivalence from the general theory under certain assumptions. All that this equivalence seems to mean physically is that the two properties of inertia and gravitation are linear functions of the "quantity of matter" or mass. This should not cause too much surprise. So is the energy produced in the transformation of mass, a linear function of the latter. So is the entity with the dimensions of mass appearing in the equation for the postulated short-range force, linearly proportional to the quantity of matter or mass of the particle in question. It is quite conceivable that matter has more than one property which depends on what we denote by the omnibus name "mass", each of which is linearly related to the mass and is therefore, also dimensionally identical. One may recall that the term energy also, is applied to various seemingly different entities. But let us see in some detail what efforts were made to clarify basic notions in mechanics even before Einstein.

Euler defined mass as the ratio of force to acceleration. Obviously it was the inertial mass which was thus defined. Saint-Venant defined the mass-ratio on the basis of the law of elastic collisions. Mach in an approach similar to Euler's, defined mass-ratio of two bodies as the negative inverse ratio of the mutually induced accelerations of the two bodies. The force in Mach's definition is the mutual gravitational attraction, accelerating the two bodies in opposite directions; hence the *negative* inverse ratio. But it is not possible to have two bodies only in isolation under each other's gravitational attraction. Pendse^{47,48} has shown that extension of Mach's method to a larger number

of bodies leads to difficulties.

While Mach questioned the notion of mass, Kirchoff, Boltzmann and Hertz raised doubts about the need or legitimacy of the concept of force, which Hertz⁴⁹ called as a "sleeping partner" in the business of mechanics. The three considered only space, time and matter (mass) as the basic conceptual elements. Let us see why.

Mass can be seen and localized but where does force reside? Is "force" not merely a name given to the cause of change in motion and then by extension also to the hypothetical agency tending to cause change in motion? Is the concept of force therefore necessary? Hertz and Boltzmann following Kirchoff's dictum that physics only describes phenomena but does not unravel their essence, tried to banish force from physics. In discussing the difficulty of the notion of force, Hertz⁵⁰ asked how an inert stone, swung in a circle with a rope by a boy, can pull the boy with a force. The boy applies a muscular force to deflect the stone from a straight path into a circular trajectory and Newton's third law demands that the stone exert an equal reactive force on the boy. (There are good reasons to question the necessity of the concept of force but in raising the above doubt Hertz seemed to reject the idea of inertial force.) Hertz, therefore, developed a mechanics, using the notions of mass and acceleration but not of force: the masses move in space and time according to a geodetic principle. It is strange that although Hertz adopted a geodetic principle himself, he was rather critical of such ideas. Discussing Gauss's principle of least constraint, he⁵¹ said that "..... we cannot, in using Gauss's principle, avoid suggesting the idea that we are not only stating a fact, but also the cause of this fact. We cannot assert that nature always keeps a certain quantity, which we call constraint, as small as possible, without suggesting that this quantity signifies something which is for nature itself a constraint — an uncomfortable feeling. We cannot assert that nature acts like a judicious calculator reducing his observations. There is undoubtedly a special charm in such suggestions. Still it must be confessed that the charm is that of mystery"

Hertz like Newton stands out as a great mathematical, as well as an experimental physicist; Braithwaite⁵² has remarked that Hertz was also the most philosophically profound of the nineteenth century physicists. But his system of mechanics al-

though logically elegant, is difficult to work with and rather barren. As Boltzmann⁵³ pointed out, even the simple phenomenon of collision of two elastic bodies cannot be worked out in Hertz's mechanics without making some arbitrary assumptions. Hertz's system remains a grand physical and logical curiosity.

8. *The Reign of Relativity*: So great were Newton's discoveries that the poet Pope was inspired to compose the now famous epitaph:

Nature and Nature's laws lay hid in night:
God said, 'Let Newton be!' and all was light.

Wordsworth expressed himself similarly; Newton's statue inspired him to say that it was a marble index of a mind for ever. Lagrange thought that Newton was the greatest genius that ever lived. But everything is subject to the law of change and mutability — even Newton's laws. Nature will never reveal fully what Shakespeare called its infinite book of secrecy.

Newton's laws did not last, but so great is the reputation of relativity (which replaced Newton's laws) for its obscurity that Sir John Squire in answer to Pope's epitaph said:

But not for long: the Devil howling "Ho!
Let Einstein be!" restored the status quo.

And to this doctrine of relativity we now turn. The phrase "The principle of relativity" has taken a metaphysical aura. It would be much preferable to call it by a slightly longer name, "the principle of relative motion".⁵⁴ Now, Descartes and Newton's first law of motion already seemed to imply this principle of relativity of (uniform) motion. If a body continued in its state of motion (whatever this might be) unless acted upon by a force, it would appear that all bodies in any state of uniform motion were in a sense equivalent. One might expect (although this does not rigorously follow theoretically) that the laws of mechanics for bodies in such an acceleration-free state, would be the same; experiments carried out on such bodies (say a train in uniform motion) could not tell what their state of motion was; experiments could only find motion of one body relative to another therefore, there was no absolute standard of rest

with reference to which velocity need be assigned. And various mechanical experiments fulfilled these expectations.

However, developments in electromagnetism and optics seemed to indicate the possibility of measuring the absolute motion of a body like the earth in space. With the accumulation of experimental evidence for the wave nature of light and of electromagnetic radiation the physicist found it necessary to postulate an ether as the carrier of electromagnetic waves. It was then not possible to understand how waves could be propagated without a medium to carry the waves. It therefore appeared that all material bodies were in motion relative to this omnipresent medium or ether. A number of optical and electromagnetic experiments were then devised to measure the motion of bodies relative to this ether, but without success. The null result of Michelson-Morley experiment in these connections caused a lot of concern to the physicists. This was the state of affairs when Poincaré, soaked in the available experimental data, turned his attention to this problem. As early as 1895 while discussing the experiment of Michelson, and other observational data, he⁵⁵ came to the conclusion that it is impossible to render manifest the absolute motion of matter and that it is possible to measure only the velocity of one body relative to another. In 1900, he⁵⁶ christened this idea as, "The principle of relative motion." However, following Lorentz, he then used an incomplete equation for the transformation of coordinates when passing from one system (x, t) , to another system (x', t') having relative velocity v , viz. $t' = (t - vx/c^2)$ instead of $t' = \beta (t - vx/c^2)$ with $\beta = (1 - v^2/c^2)^{-\frac{1}{2}}$, where c is the velocity of light. In 1902 he⁵⁷ used the appellations "The law of relativity" and "The principle of relativity", to signify that it is possible to ascertain only the relative motions of bodies. He then said that there is no absolute time and that we have no intuition of the simultaneity of events occurring at different places. In an address delivered in U.S.A. in 1904 he⁵⁸ clearly enunciated, "The principle of relativity, according to which the laws of physical phenomena should be the same, whether for an observer fixed, or for an observer carried along in uniform movement of translation....." He also predicted a new mechanics in which the velocity of light would be the upper limit of velocities. However, these ideas were still only philosophical and speculative. The first physically important step was taken by Lorentz in 1904 in response to Poincaré's⁵⁹ remark that Lorentz had been intro-

ducing new hypothesis to explain each experimental result and that this process might be repeated every time a new result arrived. Lorentz⁶⁰ therefore set out to show that relevant "electromagnetic actions are entirely independent of the motion of the system.... The only restriction as regards the velocity will be that it will be less than that of light". Lorentz then posited the equations of transformation, later (1905) named after him by Poincaré, and applied these equations to show that mass increases with velocity. This transformation is the heart of the theory of special relativity. Poincaré⁶¹ immediately saw that these equations meant that only relative motion could be ascertained whether in mechanical or in electromagnetic (and optical) experiments conducted on the earth or any other body. He also further refined Lorentz's mathematical analysis and gave the famous formula for the composition of two velocities v and w as $(v + w)/(1 + vw/c^2)$, instead of the classical $(v + w)$. All this happened before Einstein's paper was published in 1905. It also appears that Einstein was aware of his predecessors' related works⁶².

While Poincaré proceeded with the development of the new theory of relativity of motion, he did not abjure the notion of ether, or of absolute effects in the case of accelerated motion. In the case of a body (say the earth) subjected to linear or rotational acceleration, it is possible to determine the magnitude (and direction) of acceleration *without* reference to any other body, i.e. by observations confined to the body itself, e.g. the Foucault pendulum in the case of a rotating body, or an accelerometer in the case of a body linearly accelerated. However, he never physically defined his ether. The person who unequivocally proclaimed the principle of relative motion and *derived* the Lorentz equations (not satisfactorily though)⁶³ was Einstein.⁶⁴ He⁶⁴ also derived the relativistic equation for the Doppler effect.

The special theory did not merely explain known phenomena and discrepancies. It did more. In accordance with Popper's idea, the vitality of a new theory depends not only on its conformity with known phenomena and results but also on what further this theory predicts. Relativity theory predicted new laws of motion in which the mass, space and item measures change with the observer. The main basic formulae were:

$$x' = \beta (x - vt); y' = y; z' = z; t' = \beta (t - vx/c^2); m' = \beta m; \beta = (1 - v^2/c^2)^{-\frac{1}{2}} \geq 1.$$

Here the coordinates of the two systems S and S' in which ob-

servations are made are (x, y, z, t) and (x', y', z', t') respectively and v is the velocity of the system S' relative to S in the direction of x and x' axes, which without loss of generality, are oriented so as to coincide. The mass m at rest in system S is measured as m' in system S' . It is important to notice that (x, y, z, t) and (x', y', z', t') are measures *within* the respective systems while m is the measure of the given mass stationary in S and m' the corresponding measure in S' in which the mass is observed to be in motion. In other words the transformation equations show that space and time measures of different systems are internally not the same. For example, the time between two occurrences (events) will be different in the two systems S and S' . The time-interval between two events occurring on the common x - x' axis at a given (fixed) space point $(x, 0, 0)$ of S as measured in S may be $(t_2 - t_1)$ which will be recorded as $(t'_2 - t'_1) = \beta (t_2 - vx/c^2 - t_1 + vx/c^2) = \beta (t_2 - t_1)$ in S' . This relation holds good as $(t_2 - t_1) \rightarrow 0$, i.e. $\frac{dt}{dt'} = 1/\beta$.

I like to make the point that this unexpected result follows from the transformation equations but *not* from the principle of relativity as such. The transformation equations themselves were (in later publications) derived by Einstein⁶⁵ using the postulate (known as the second postulate) to the effect that the velocity of light is constant in all directions and at all points for all observers, and assuming that the relative velocity of S' as measured from S , and of S as measured from S' is the same (viz., v). No doubt, velocity was assumed to be a "relative" measure but this does not imply that *all* physical quantities are relative. The principle of relativity is too extensive a proposition to be incorporated fully in any mathematical analysis, i.e., for it to follow, necessarily from any set of equations. In any mathematical analysis, i.e., (e.g. derivation of Lorentz transformations) some phenomena may be assumed as relative but, obviously, the assumption that *all* phenomenon are relative cannot be incorporated and used in any analysis. Therefore, as Poincaré⁶⁶ and Lorentz⁶⁷ asserted, whether the principle of relativity holds or not will always be decided by experiment and it is not impossible for an experiment to contradict it, without contradicting the Lorentz transformation or the second postulate. Similarly, Bondi⁶⁸ has observed that "... special relativity is not something that absolutely must be true, it is merely the statement that for a large range and variety of experiments the preferred velocity is

irrelevant." (Note the words 'preferred velocity'.) In Einstein's derivation mentioned above only the relativity of velocity is assumed. In fact it can be shown⁶⁹ that even this assumption is not necessary; the second postulate alone suffices to get the Lorentz transformations. It can also be shown, that the relativity of uniform motion or velocity is also a consequence of Lorentz transformations. The Lorentz transformations show that the space and time measures of various inertial systems are different, and these differences can be explained only if it is granted that the systems at rest relative to the fixed stars stand in a class apart ($\beta = 1$). Of course, the Lorentz transformations imply a high degree of relativity for all inertial systems in uniform motion relative to the fixed stars ($\beta > 1$ but constant for each system). The usual laws of mechanics as well as the constancy of velocity of electromagnetic (and optical) propagation obtain in such inertial systems. But the internal measures of space and time are, generally speaking, different for different systems. By a "high degree", therefore, I mean validity for a large range of experiments, but not always, so that the "preferred velocity" in relation to the fixed stars may be relevant in some experiments and for some laws of physics.

It turned out that although space and time measures assigned by different observers might be different, the total interval equal to $(x_2 - x_1)^2 + (y_2^2 - y_1^2) + (z_2^2 - z_1^2) - (c^2 t_2^2 - c^2 t_1^2)$, is the same for all observers. This interval is like a length in a four-dimensional space, (x, y, z, γ) where $\gamma = ict$, as Poincaré⁷⁰ first pointed out in 1906.

Later (1916) Einstein⁷¹ attempted an extension of the idea of relativity to all kinds of motions. In the process he discovered a new theory of gravitation.

The motivations for Einstein's general theory of relativity came from six different ideas: (i) all motion is relative and not merely uniform motion; (ii) equivalence of the laws of physics between a system held at rest in a gravitational field on the one hand and an accelerated system on the other; (iii) equivalence of gravitational and inertial masses; (iv) Mach's principle, viz. the inertia of any mass is due to its interaction with the rest of the masses of the universe; (v) non-Euclidean character of space-time geometry in general, i.e. in the case of accelerated motion or gravitational fields; and (vi) the laws of physics have the same form in any system of reference, i.e. the laws of physics have a covariant form or they can be expressed by tensor equations.

The first four ideas had only an inspirational significance and do not appear in the development of the theory proper as we shall see presently. Long after Einstein propounded his theory, it appeared possible to *deduce* from the theory the equivalence of gravitational and inertial masses (as we mentioned earlier) and Mach's principle (in some form). It appears that even item (v) is not essential for the development of the theory because one is still free to regard the geometry as Euclidean and to consider the coefficients of the metric of space-time as physical entities characterizing the gravitational field⁷². In fact this as a better alternative⁷³. Here we have an interesting case where ideas inspire the discoverer of a theory but actually play little part in the development of the theory. The other ideas are also mentioned in literature which too are not essential for the formulation of Einstein's theory. These are: (i) gravitational effects observed so far are only attractive, unlike electricity and magnetism and that attraction exists between *like* entities ("positive" masses); (ii) gravitational effects cannot be shielded by a material screen quite unlike electric and magnetic effects.

It is no doubt remarkable that gravitational coupling cannot be physically broken but it does not then follow as is usually asserted that the geometry of space-time is determined by matter at a distance⁷⁴. It is not inconceivable that a physical effect may alter the geometry of space-time and yet be such that it can be screened. For example, it is to be assumed that the energy associated with an electromagnetic field alters space-time structure (energy and mass are equivalent), but electromagnetic effects can be shielded. Quite often, in relativity we let the charm of a new idea work too much upon us. However, the fact that gravitation is universal and there is no barrier against it, makes it difficult to isolate a system for experimental purposes. An electromagnetic field can be absorbed, augmented or diverted by matter and nullified by other charges and poles but a gravitational field although caused by matter, seems to be affected by other matter only in the sense of superposition. The above statement is true of static gravitational fields and possibly also of stationary fields but not when the fields are changing. Variations in the field apparently cause gravitational radiation and this radiation can be absorbed by a mass⁷⁵, i.e. it can be screened.

A brief outline of Einstein's theory of gravitation is given in the sequel in order to see its conceptual and analytical elements.

The space-time $(x_\mu, \mu=1,2,3,4)$ is characterized by an invariant metric :

$$ds^2 = g_{\mu\nu}(x) dx^\mu dx^\nu \quad (\mu, \nu = 1,2,3,4) \quad \dots \quad (1)$$

This form is a generalization of the metric of special relativity for inertial systems in which :

$$g_{\mu\nu} = \begin{vmatrix} +1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{vmatrix}$$

The co-efficients $g_{\mu\nu}$ all functions of x 's, depend on the masses present and their motions. It will be seen that $g_{\mu\nu}$ constitute a covariant tensor of the second rank. Obviously a knowledge of the space-time structure (i.e. of $g_{\mu\nu}$) must be available in advance before the geometry and location of the masses and the details of the motions can be assigned but the space-time structure itself is dependent on the masses present. So at the very outset we are caught in a circular argument. However, successive approximations can be used, and in some cases, such as a spherically symmetric distribution of matter, exact solutions can be obtained. How do $g_{\mu\nu}$ vary in space-time with the distribution of matter? The guiding light here is the requirement that the equations of the gravitational field outside matter, involving $g_{\mu\nu}$, should have tensor form or be covariant. It turns out that for the problem in hand this is quite a powerful requirement leading to the solution looked for. As is well-known if a tensor vanishes in any coordinate system, it vanishes in every other system. Of course, there is no reason in logic why a law of physics should have a tensorial form but the approach is tentative and subject to verification by observation. In fact it might be mentioned that some of the more important conservation laws cannot be put in tensor form, as Bondi⁷⁶ has pointed out. The only tensors which are functions of $g_{\mu\nu}$ and of derivatives of $g_{\mu\nu}$ of the second or lower order, happen to be just two in number, $g_{\mu\nu}$ itself and a fourth order tensor $B_{\mu\nu\sigma}^\epsilon$ called the Riemann-Christoffel tensor having the following form :

$$B_{\mu\nu\sigma}^{\epsilon} = \{\mu\sigma, \alpha\} \{\alpha\nu, \epsilon\} - \{\mu\nu, \alpha\} \{\alpha\sigma, \epsilon\} + \frac{\partial}{\partial x_{\nu}} \{\mu\sigma, \epsilon\} - \frac{\partial}{\partial x_{\sigma}} \{\mu\nu, \epsilon\},$$

$$\text{where } \{\mu\sigma, \alpha\} = \frac{1}{2} g^{\alpha\lambda} \left(\frac{\partial g_{\mu\lambda}}{\partial x_{\sigma}} + \frac{\partial g_{\sigma\lambda}}{\partial x_{\mu}} - \frac{\partial g_{\mu\sigma}}{\partial x_{\lambda}} \right), \text{ etc.}$$

If $B_{\mu\nu\sigma}^{\epsilon} = 0$, it can be shown that coordinates can be found such

that $g_{\mu\nu}$ are constants (i.e. the space-time is then flat, or free from gravitational effects in the chosen coordinate system.⁷⁷

Putting $\epsilon = \sigma$ in the expression for $B_{\mu\nu\sigma}^{\epsilon}$, gives a tensor of the second rank.

$$G_{\mu\nu} = \{\mu\sigma, \alpha\} \{\alpha\nu, \sigma\} - \{\mu\nu, \alpha\} \{\alpha\sigma, \sigma\} + \frac{\partial}{\partial x_{\nu}} \{\mu\sigma, \sigma\} - \frac{\partial}{\partial x_{\sigma}} \{\mu\nu, \sigma\}.$$

$G_{\mu\nu}$ too are wholly functions of $g_{\mu\nu}$ and of their first and second partial derivatives.

This part of the analysis is mostly mathematical. The physics was brought in as follows: Einstein postulated the law $G_{\mu\nu} = 0$ for space-time outside matter under the sway of a gravitational field. $G_{\mu\nu}$ is rather a forbidding entity in the craggy world of tensors. Looking at its full expression one might cry out with Milton:

No light, but rather darkness visible. (*Paradise Lost*, I. 63)

But the genius of Einstein could see that this flummoxing expression contains the law of the gravitational field due to matter. What Boltzmann said about Maxwell's equations could here be repeated, 'Who was the God who wrote these lines?' Perhaps, in the whole history of science (mathematics excluded) there is no other single act of postulation, so far removed from the results it predicted.

This law contained not only the basic conditions necessary to determine $g_{\mu\nu}$ for the gravitational field due to given masses,

but it already implied also the equations of motion of a particle in the gravitational field, as later investigations showed⁷⁸. The equations of motion turned out to be those of a geodesic when the mass of the particle is negligible i.e., the motion is such that $\delta \int ds = 0$. One does not, therefore, have to assume the geodesic condition as a separate postulate. This would surely have delighted Hertz.

The $g_{\mu\nu}$ outside a spherical mass with radial symmetry were worked out by Schwarzschild, soon after Einstein announced his theory and the experimental verifications of general relativity are all verifications of this solution of Schwarzschild's. In deriving this solution, it is assumed that Newton's theory is a first approximation. It appears, however, that this solution can be obtained from the special relativity and the Newtonian theory of gravitation⁷⁹, without recourse to the apparatus of general relativity. The greatest triumph of the new law of gravitation was that it predicted an advance of the perihelion of Mercury which removed a long standing discrepancy between the observed motion and that calculated from Newton's theory.

A different equation for the gravitational field *inside* matter (such as a gas) was given by Einstein but there are no significant experimental consequences of this equation which can be put to observational tests. Also this equation is logically not as simple as that for empty space in the presence of matter. Later, Einstein himself expressed dissatisfaction with the equation for the gravitational field inside matter⁸⁰. Einstein and his collaborators then modified the theory, considering matter as consisting of singularities instead of a bounded continuum.

Einstein's theory of gravitation is basically different from Newton's — not merely in its mathematical formalism. For example, Einstein's theory can say how light and clocks behave in a gravitational field, matters on which the Newtonian theory is silent. Conceptually also, the notion of the 'field' defined by a metric of space-time is a great step forward because, in the words of Einstein⁸¹, fields are the physical states of space. To return to our point regarding the assumptions on which the general theory is based, we may summarize them as follows:

- i) The gravitational field is characterized by a symmetric metric tensor $g_{\mu\nu}$ satisfying equation (1). In Newton's theory the gravitational field is a scalar.

ii) The law of gravity field in space around matter is

$$G_{\mu\nu} = 0, \text{ where various } G_{\mu\nu} \text{ are some functions of } \xi_{\mu\nu}.$$

iii) Newton's theory is a first approximation.

The equivalence principle, etc., are hardly invoked in working out the theory.

9. *Concluding Remarks*: It will be wrong to assume that in Einstein's theory we have the ultimate theory of gravitation and motion. We may catalogue some of the difficulties of the theory.

- i) How is it that in spite of the masses of the universe, the local metric is observed to be flat, i.e. that of special relativity? This is the problem of the existence of inertial systems.
- ii) Why is gravitation attractive? The theory of Hoyle and Narlikar⁸² answers this question satisfactorily.
- iii) How to derive the value of the gravitational constant G ? At present experiments for the determination of G employ Newtonian ideas and methods. As Synge⁸³ has pointed out, the fact is that it is difficult even to formulate simple dynamical problems in general relativity. This difficulty is not merely mathematical but conceptual.
- iv) It is not yet possible to localize energy and momentum of a gravitational field in any physically satisfactory way⁸⁴.
- v) The present verifications of the theory are really only verifications of three observable consequences of a particular solution of $G_{\mu\nu} = 0$. (Schwarzschild's for a static field around a heavy mass).
- vi) Singularities or unphysical behaviour of the metric $ds^2 = g_{\mu\nu} dx^\mu dx^\nu$ at some values of $g_{\mu\nu}$.
- vii) Cases are known⁸⁵ where energy — tensor is zero but $B_{\mu\nu\sigma}^\epsilon \neq 0$. It cannot therefore be asserted that the curvature of space-time is the cause of gravitation.

viii) Approximate methods are unreliable. An approximate solution of the field equations for a given distribution of matter is an exact solution for some other distribution. For example, if we use an approximate procedure to find a solution to empty-space equations, we may end up with an exact solution for a space with anisotropic pressures in it⁸⁶.

But this is the way all theories ultimately go. Einstein's is still the best theory of gravitation. No experimental contradictions of the theory have yet come to light and it can scarcely be faulted on its basic ideas. But it is obvious that one day another theory will replace it. Numerous theories of gravitation have been proposed after Einstein's. Notable among these are those due to Whitehead⁸⁷ and in recent years due to Hoyle & Narlikar⁸² mentioned earlier. The very latest ones (sounds like a fashion-parade!) are due to Rastall⁸⁸ and Deser and Laurent⁸⁹. At present these theories are observationally indistinguishable. Conceptually all the authors claim their theories to be different from Einstein's. Whitehead⁸⁷ maintained the inherent division between geometry and physics, the former expressing the uniform relatedness of nature and the latter its contingent relations, as he put it. A spherically symmetric mass with variable density according to Whitehead's theory has an external metric different from Einstein's but not yet capable of experimental verification. Hoyle and Narlikar's theory is no doubt an advance on Einstein's. Mach's principle is fully incorporated and the sign of the gravitational constant comes out of the theory almost like a rabbit out of a hat. However, masses are assumed to have the same sign. It is said that there can be no world with one particle, the least number being two. But it is not clear what a particle is and why the world cannot be regarded as one "particle". Each mass is said to arise from interaction with the rest of the universe⁹⁰ but this alone does not explain why various masses are different, e.g., why 1 gm and 1 kg masses differ so much while the rest of the masses of the universe remain almost the same for the two. Rastall's theory assumes space-time to be formally flat and the gravitational field to be a scalar potential, not a tensor. Deser and Laurent's analysis assumes gravitation to be a spin-two field; they get the metric around a spherical mass in the form :

$$ds^2 = \left(1 - \frac{1}{r}\right) dt^2 - \left(1 + \frac{1}{r}\right) dr^2 - r^2 d\Omega^2.$$

This is an exact form with the coefficient of dr^2 as $\left(1 + \frac{1}{r}\right)$ instead of $\left(1 - \frac{1}{r}\right)^{-1}$ as in the case of the Schwarzschild metric.

These developments are signs of health, but not yet of final achievement. A new theory of gravitation must predict new and testable results and thus be distinguishable from Einstein's theory, before it can replace it. This is a legitimate demand and will no doubt be fulfilled one day as the edge of analysis and experimental precision moves forward. Already Dicke's analysis and observations seem to show that the oblateness of the rotating sun should account for a centennial advance of 4" for the perihelion of Mercury.

It does not diminish the great significance of Einstein's theory of gravitation to say that it will surely be replaced. What Shelley said in *Alastor* will remain true of the physicist's quest for the laws of nature, always.

I have watched
Thy shadow, and the darkness of Thy steps,
And my heart ever gazes on the depth
Of thy deep mysteries

and though ne'er yet
Thou hast unveiled thy inmost sanctuary.

Is it a sad thought that one can never taste the final consummation in physics?

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1. Introduction

During the last few years there has been a spectacular growth in technology of superconducting magnets and materials. A variety of superconducting alloys and compounds are now available and steady magnetic fields as high as 150 kOe have already been generated. There seems no doubt that this limit will be steadily raised even higher towards 200 kOe or more. As compared to conventional electromagnets, superconducting magnets are far more compact, cheaper to operate and offer a better stability. They have become an integrated part of cryogenic laboratories for the nuclear and solid state research where fields in the range of 40-100 kOe are required over a relatively small volume of a few cm³. Even in such large installations and sophisticated projects as the hydrogen bubble chamber, magnetohydrodynamic power generation, and the shielding of the space vehicles against radiation, the superconducting magnets are being chosen in preference to the conventional electromagnets. The object of this paper is to give a brief account of the evolution of technology of superconducting magnets, relating their design and performance. In order to appreciate fully the outstanding utility of superconducting magnets, it is worthwhile to examine first the power dissipation in conventional electromagnets.

2. The Conventional Electromagnet

The generation of high magnetic fields using electromagnets wound with a conventional conductor, such as copper, has been fairly extensively studied for many years. But, in such magnets, due to the finite resistance of the copper wire, the electrical

power loss through Joule heating in solenoid windings is enormous. The field-power relation may be calculated as follows. If j is the current density and ρ_n , the resistivity of the conductor, the power P dissipated over the whole volume V_0 of the conductor in the solenoid is given by

$$P = j^2 \rho_n \int_0^{V_0} dv = j^2 \rho_n V_0 = j^2 \rho_n a_1^3 2\pi\beta (\alpha^2 - 1) \lambda, \quad \dots \quad (1)$$

where a_1 , α and β are as defined in fig. 1. λ is called the 'space factor' given by V_0/V_1 , where V_1 is the volume of the coil $\equiv a_1^3 (2\pi\beta) (\alpha^2 - 1)$. Since the conductor carries some insulation, and also for the fact that some space is allowed for the cooling vents, $V_1 > V_0$ and $\lambda < 1$. The field at the centre of the solenoid is given by¹

$$H_0 = j a_1 \lambda F(\alpha, \beta), \quad \dots \quad (2)$$

where $F(\alpha, \beta)$ is a geometrical factor given by

$$F(\alpha, \beta) = \left(\frac{2\pi\beta}{5} \right) \ln \left\{ \frac{\alpha + (\alpha^2 + \beta^2)^{\frac{1}{2}}}{1 + (1 + \beta^2)^{\frac{1}{2}}} \right\}. \quad \dots \quad (3)$$

Substituting the value of j from equ. 1 in equ. 2 gives the field-power relation in the form

$$H_0 = G(\alpha, \beta) \left(\frac{P \lambda}{\rho_n a_1} \right)^{\frac{1}{2}}, \quad \dots \quad (4)$$

where $G(\alpha, \beta)$ is another geometrical factor given by

$$G(\alpha, \beta) = \left(\frac{2\pi\beta}{\alpha^2 - 1} \right)^{\frac{1}{2}} \frac{1}{5} \ln \left\{ \frac{\alpha + (\alpha^2 + \beta^2)^{\frac{1}{2}}}{1 + (1 + \beta^2)^{\frac{1}{2}}} \right\} \quad \dots \quad (5)$$

Thus, from equ. 4, the optimization procedure for the minimum power consumption is to maximize G . However for most conventional solenoids, operating at room temperature, G is relatively insensitive to geometry and equ. 4 may be expressed in a useful form²

$$H_0 = 1.1 \times 10^2 (P/a_1)^{\frac{1}{2}} \quad \dots \quad (6)$$

where P is in megawatts, a_1 in cm. and H_0 in kOersteds.

Thus, for a magnet with the inner radius of 1 cm, to produce a

field of 100 kOe, the power dissipation is about 1 megawatt, and for a field of 200 kOe the dissipation is of over 3 megawatts. The power dissipation increases rapidly with increasing bore diameter. As an outcome of the large power dissipation, the temperature of the solenoid increases rapidly and it becomes necessary to have a large flow of cooling water to keep the temperature of the system below its 'burn out' limit.

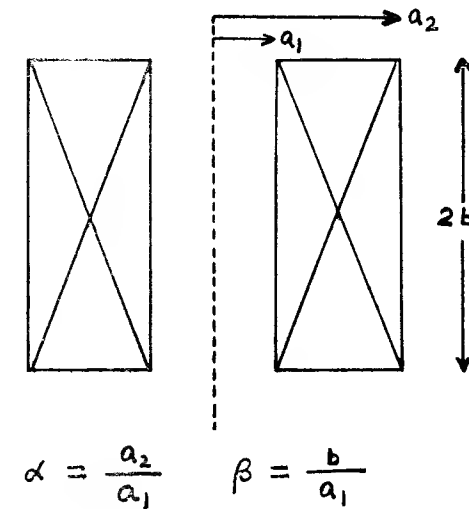


FIG. 1 : The magnet parameters.

Superconducting magnets, on the other hand are free from these complications. Their resistance being almost zero, they have practically no power dissipation. They can be operated by simple power supplies and the circulating currents can be easily switched into persistent mode so as to create a permanent magnet system. Such a magnet then does not require any external power supply except that required to maintain the static cryogenic environment, which may be roughly estimated as a 10-kW refrigerator. Thus we have in effect a power saving of at least by a factor of 100 at 100 kOe; this factor will be even more at higher magnetic fields.

3. Superconducting Aspects

The phenomenon of superconductivity was discovered by Kamerlingh-Onnes in 1911. For mercury, he found that at a temperature little above 4°K, its resistance dropped abruptly

to a value experimentally undetectable. Later, he observed a similar occurrence in other pure elements tin and lead. This phenomenon, he called superconductivity and the temperature at which it occurred, the critical temperature. Onnes immediately had in mind the production of strong magnetic fields without dissipation of Joule heat. But to his great disappointment he discovered that the phenomenon abruptly disappeared in the presence of magnetic fields when the latter exceeded certain critical value H_c of the order of a few hundred Oersteds. This situation has remained unchanged to the present day for pure superconducting elements. As a result of this set-back, for over the next forty years superconductivity remained merely of pure academic interest, with no apparent prospect of useful application.

The most significant advances came in early sixties after Abrikosov³ theoretically predicted a whole new class of superconducting materials having magnetic properties quite different from those of pure elements. Fig. 2a plots $-4\pi M$ against H , M being magnetisation per volume. In this figure the magnetisation behaviour of this category (shown by curve no. 1), known as a type II superconductor is contrasted against that of a pure element, termed as a type I superconductor (the curve is shown by the vertical broken lines at H_c). The field penetration in a type II superconductor begins at a field denoted by H_{c1} (termed as the lower critical field) which is somewhat less than H_c , and it continues until a field H_{c2} (see fig. 2a) is reached when the material is no longer superconducting. H_{c2} , termed as the upper critical field, is greater than H_c . Below H_{c1} , the bulk material is entirely superconducting while above H_{c2} it is completely normal. Between H_{c1} and H_{c2} it is called the mixed state. Abrikosov showed that the field penetration in the mixed state occurred in the pattern of a regular lattice of vortex lines. A vortex line may be roughly defined as a cylindrical filament of normal material enclosed by rings of supercurrents. The radius of the filament being very small, even in appreciably high fields the material carries practically no resistance in the mixed state. The upper critical field depends upon such parameters as the normal state resistivity, the critical temperature and the coefficient of electronic specific heat. By controlled alloying these parameters can be conveniently altered so as to enhance the value of the upper critical field.

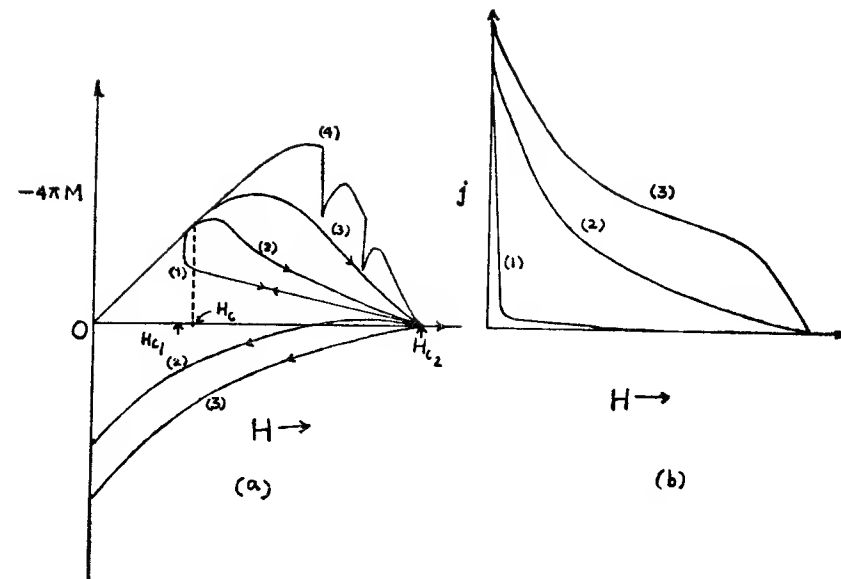


Fig. 2a Reversible and irreversible magnetisation curves of a type II superconductor. The curve in broken lines shows the magnetisation behaviour of a type I superconductor.

2b Critical current curves of a type II superconductor.

For making superconducting solenoids, however, a material having just a large upper critical field is not adequate enough, it must also carry high transport current densities in large magnetic fields. A homogeneous and defect-free specimen (with the magnetisation curve no. 1 in fig. 2a) in the mixed state fails to carry any transport current in a transverse magnetic field (see curve no. 1 in fig. 2b) because in this situation there is always a force $j \times H$ (the Lorentz force) which tends to sweep the field out of the material. Thus, in order that a material may carry high current densities in the mixed state it must have inhomogeneities and defects which would cause hindrance to vortex motion. Magnetisation curves of inhomogeneous specimens show magnetic hysteresis (curves no. 2 and 3 in fig. 2a) and such specimens can also sustain high current densities (curves no. 2 and 3 in fig. 2b). These materials are called 'hard superconductors'. The relationship between the lattice defects and superconducting properties has been reviewed recently by several authors.^{4, 5, 6}

4. High-Field Materials

In parallel with the rapid theoretical developments, some of which are mentioned above, there began an equally spectacular growth in experimental work on superconducting alloys and compounds, and during early sixties several materials were discovered which remained superconducting at higher temperatures and in field strengths of several thousand Oersteds (see Table 1). These materials showed hysteresis and carried high current densities in high magnetic fields and thus became immediately of technological interest. Next obvious step was to fabricate these materials in a form suitable for winding magnets. This, however, turned out to be one of the main obstacles in making of high-field solenoids, and, in fact, till now due to fabrication difficulties alone, magnets of V_3Si and V_3Ga have not yet been made.

Table I

Material	Critical Field at 4.2°K (Oe)	Critical Temperature (°K)
Mo - 38 at. % Re	25000	12.3
Nb - 25 at. % Zr	75000	11.0
Nb - 60 at. % Ti	125000	8.5
Nb ₃ Sn	225000	18.2
V ₃ Si	225000	16.8
V Ga	195000	14.0

Fabrication of Nb-Zr and Nb-Ti has been relatively easy. These materials are ductile and present little problem in drawing wires of required dimensions. A Nb-Zr magnet is convenient up to fields of 50 kOe while Nb-Ti up to 100 kOe. For field requirements exceeding 100 kOe one has to use a Nb₃Sn magnet.

As compared to Nb-Zr and Nb-Ti, the fabrication of Nb₃Sn has presented certain difficulties. The material is extremely brittle and cannot be drawn into wires like either of the two materials. There are essentially two methods followed. In the first method, known as 'wind and react' method, a niobium wire is coated with tin and is wound into a solenoid. The solenoid is then cooked in a furnace for several hours at 950°C. During this heat-treatment Nb and Sn react to form Nb₃Sn. This method is satisfactory for making small laboratory solenoids but is obviously unsuitable for the magnets required for large installations.

The other method involves making of flexible tapes by depositing thin films of Nb₃Sn on a suitable substratum. To make a solenoid, the superconducting tape is wound into flat discs (pancakes), and a stack of discs is connected in series. (fig. 3.) Disc to disc short-circuiting is avoided by using insulating spacers between discs. 100 kOe, 1.5 inch bore laboratory magnet recently brought out by General Electric Company is of this type.

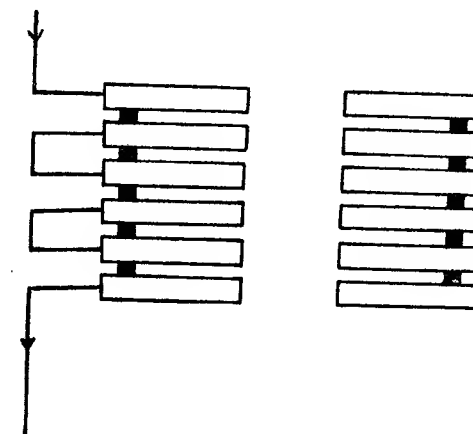


Fig. 3 : Superconducting magnet in pancake-type construction.

5. The Performance

The early experiments with superconducting magnets posed two rather unexpected problems which faced the solenoid designer. They were the degradation effect, that is, the failure of the solenoid to carry the current as expected from short-sample tests, and the destruction of the solenoid resulting from the accidental transition from superconducting to normal state. Hard superconductors in normal state have very high electrical resistivity and Joule heating resulting at the transition is sufficiently large to destroy the coil. The origin of degradation, which results in the premature transitions at low current densities, is in flux jumping. The movement of vortex lines in hard superconductors is discontinuous and jerky (curve 4 in fig. 2a) and if a sufficiently large flux jump occurs it nucleates a normal zone. If the thermal environments of the coil are poor, the normal zone grows and spreads right through, and this results in the discharge of the coil.

The above difficulties are overcome by using superconducting wires coated with copper. This has two effects. The resistivity of copper being low it serves as an efficient shunt when the accidental transition to the normal state occurs, and thus protects the superconducting wire. Secondly, the copper coating enhances the current-carrying capacity of the wire by improving its thermal environment and providing a better cooling.

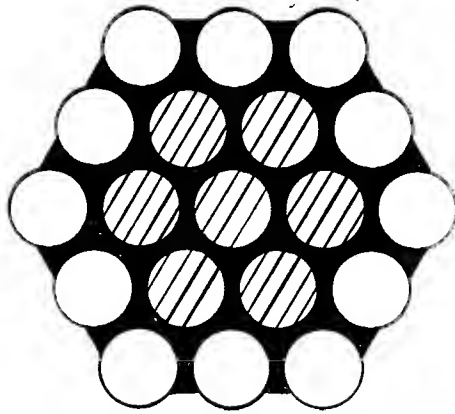


Fig. 4a: A composite superconducting cable consisting of 7 copper coated superconducting strands enclosed by 12 copper strands.



Fig. 4b: Stekly-type composite cable. 9 superconducting strands are embedded in a copper strip.

The stable coils are made by using cables consisting of several separate copper coated superconducting strands. The use of extra strands of copper around the superconducting strands gives an additional stability. (Fig. 4a.) Indium and lead are generally used as impregnating materials. They ensure a good flexibility and maintain a satisfactory electrical bond between strands. Stekly and his collaborators⁷ have made a cable consisting of 9 Nb-Zr wires embedded in a copper strip. (Fig. 4b.) Solenoids constructed from such a cable are entirely stable.

6. Design of Superconducting Magnets; Optimization

In the design of superconducting solenoids where power is no longer required, one is interested to know the shape of the solenoid so that the minimum length of the superconducting wire (or cable) is needed to produce the required field. This problem has been examined recently by Thomas and Bright.⁸ Equ. 2 may be written as

$$H_o = \frac{2 \pi b I}{5 A} \ln \left[\frac{\alpha + (\alpha^2 + \beta^2)^{\frac{1}{2}}}{1 + (1 + \beta^2)^{\frac{1}{2}}} \right] \quad \dots \quad (7)$$

where I is the current in the wire of diameter d , and A is the cross-sectional area allowed for each turn. $A = 2d^2$ and the space factor $\lambda = \pi (d/2)^2 / 2d^2 = 0.39$. The above equation may be rewritten as

$$R = \beta \ln \left[\frac{\alpha + (\alpha^2 + \beta^2)^{\frac{1}{2}}}{1 + (1 + \beta^2)^{\frac{1}{2}}} \right]$$

where $R = \frac{5 H_o A}{2 \pi I a_1}$. The length of the wire is given by

$$L = \frac{2 \pi a_1^3}{A} (\alpha^2 - 1) \beta = \frac{2 \pi a_1^3}{A} Q$$

where $Q = (\alpha^2 - 1) \beta$.

The parameter R is determined by the field requirement, the current-carrying capacity of the material, the diameter of the wire available and the size of the bore required for the solenoid. Thomas and Bright⁸ have computed two sets of curves between Q and β , and between α and β for different values

of R . From the first set of curves, for a particular value of R , the value β which gives the minimum Q is determined. Using this value of β , the value of α is obtained from the second set of curves. Knowing α , β and Q , the shape of the solenoid and the minimum length of the wire required can be easily calculated.

7. Conclusion; the Upper Field Limitation in Superconductors

Superconducting magnet technology is now already well established. Further progress will clearly depend upon the discovery of new materials with higher critical temperatures, higher transport current densities, and larger critical fields. It is natural to ask if there is any upper field limitation H_{c_p} for fields produced using superconducting solenoids. The problem has been examined by theoreticians who have shown that, in fact, there is such a limit for the critical field of a material, which at 0°K is given by $H_{c_p} = 18400 T_c$ Oe, where T_c is the critical temperature in (OK). This limit arises because of the alignment of free electron spins of the normal state in the presence of the applied field which results in a decrease of its free energy, and consequently, the field required to compensate the difference between superconducting and normal state free energies is subsequently reduced. Physically, this simply means that the problem of finding materials with higher critical fields is, in fact, same as of finding new materials having higher critical temperatures. Until now, Nb_3Sn was known as the material having the highest T_c of 18.2°K. The upper field limitation for Nb_3Sn at 4.2°K is about 250 kOe. Thus to generate higher magnetic fields than this one must look for a material having the critical temperature greater than 18.2°K. Recently⁹ a compound $Nb_3(Al, Ge)$ has been discovered which possesses T_c of 20.7°K. Magnetic properties of this material have yet to be reported. If they turn out to be superior to those of Nb_3Sn the next obvious step would be to fabricate this material in a convenient form readily suitable for winding solenoids.

Acknowledgements

The author wishes to thank Madame Widmer and Monsieur Siegrist for their help in preparation of this manuscript.

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8 Explicit Sampling Distribution and the Posterior Probability Distribution of the Maximum Likelihood Estimators of Parameters of a Regular-Type Distribution Admitting Sufficient Statistics for Parameters

V. S. Huzurbazar

Explicit Sampling & the Posterior Probability Distribution

where

$$T_k = \sum_{l=1}^n v_k(x_l). \quad (1)$$

The maximum likelihood equations for the α_j are

$$\frac{\partial L}{\partial \alpha_r} = \sum_{k=1}^p \frac{\partial u_k}{\partial \alpha_r} T_k + n \frac{\partial B}{\partial \alpha_r} = 0 \quad (r = 1, 2, \dots, p).$$

Hence
$$\sum_{k=1}^p \left(\frac{\partial u_k}{\partial \alpha_r} \right)_{\hat{\alpha}_j} T_k + n \left(\frac{\partial B}{\partial \alpha_r} \right)_{\hat{\alpha}_j} = 0 \quad (r=1, 2, \dots, p). \quad (2)$$

The p simultaneous linear equations in the T_k given by (2) enable us to express the T_k in terms of the maximum likelihood estimators $\hat{\alpha}_j$. The solutions will be of the form

$$T_k = n \phi_k(\hat{\alpha}_j). \quad (3)$$

If $H(t_k)$ is the characteristic function of the T_k 's,

$$\begin{aligned} H(t_k) &= E \left\{ e^{i \sum_{k=1}^p t_k T_k} \right\} \\ &= E \left\{ e^{i \sum_{k=1}^p t_k \sum_{l=1}^n v_k(x_l)} \right\} \\ &= \left[E \left\{ e^{i \sum_{k=1}^p t_k v_k(x)} \right\} \right]^n. \end{aligned} \quad (4)$$

Since $\int f(x; \alpha_j) dx = 1$ for all α_j , we have

$$\int \exp \left\{ \sum_{k=1}^p u_k(\alpha_j) v_k(x) + A(x) \right\} dx = \exp \left\{ -B(\alpha_j) \right\} \quad (5)$$

Now the $u_k(\alpha_j)$ are p independent* functions of the p parameters α_j . We can express the α_j inversely as functions of the u_k 's. Then $B(\alpha_j)$ can be expressed in terms of the u_k 's as

$$B(\alpha_j) = b(u_k). \quad (6)$$

*The independence of the functions $u_k(\alpha_j)$ follows from the fact that the u_k can also be chosen as parameters of the distribution in place of the α_j . If the u_k are not independent, the number of essential parameters of the distribution can be reduced. This will be contrary to the assumption that the α_j are a set of p essential parameters of the distribution.

Summary : The explicit sampling distribution of the maximum likelihood estimators of the parameters of a regular-type distribution (i.e. when the range of the distribution is independent of the parameters) is obtained, thus extending the single-parameter case considered by Fisher (1934) and Pitman (1936). Explicit posterior probability distribution of the maximum likelihood estimates from a subsequent sample when an earlier sample is known, is also obtained, thus extending the previous result obtained by the present Author (1948).

1. *Introduction :* The most general form of regular-type distributions admitting a set of jointly sufficient statistics for the parameters α_j ($j=1, 2, \dots, p$), as given by Pitman (1936) and Koopman (1936) is

$$f(x; \alpha_j) = \exp \left\{ \sum_{k=1}^p u_k(\alpha_j) v_k(x) + A(x) + B(\alpha_j) \right\}, \quad (1)$$

where the u_k and B are functions of the α_j only, and the v_k and A are functions of x only.

2. *Explicit sampling distribution of the maximum likelihood estimators of the parameters of a distribution admitting a set of jointly sufficient statistics :*

Let x_1, x_2, \dots, x_n be a sample of n independent observations from the distribution yielding the maximum likelihood estimators $\hat{\alpha}_j$ of the parameters α_j . If L is the logarithm of the likelihood function, we have

$$L = \sum_{k=1}^p u_k(\alpha_j) T_k + \sum_{l=1}^n A(x_l) + n B(\alpha_j),$$

Hence (5) becomes

$$\int \exp \left\{ \sum_{k=1}^p u_k v_k(x) + A(x) \right\} dx = \exp \left\{ -b(u_k) \right\}, \quad (7)$$

which we shall use often.

$$\begin{aligned} \text{Now } E \left\{ e^{i \sum_{k=1}^p t_k v_k(x)} \right\} \\ &= \int \exp \left\{ \sum_{k=1}^p (u_k + it_k) v_k(x) + A(x) + B(\alpha_j) \right\} dx \\ &= \exp \{ B(\alpha_j) \} \int \exp \left\{ \sum_{k=1}^p (u_k + it_k) v_k(x) + A(x) \right\} dx \\ &= \exp \{ B(\alpha_j) \} \exp \left\{ -b(u_k + it_k) \right\} \text{ (writing } u_k + it_k \text{ for } u_k \text{ in (7))} \\ &= \exp \left\{ B(\alpha_j) - b(u_k + it_k) \right\}. \end{aligned}$$

$$\text{From (4), } H(t_k) = \exp \left\{ n B(\alpha_j) - n b(u_k + it_k) \right\}$$

The joint p. d. f. of the T_k 's is given by

$$\begin{aligned} \frac{1}{(2\pi)^p} \int_{-\infty}^{\infty} \dots \int_{-\infty}^{\infty} e^{-i \sum_{k=1}^p t_k T_k} H(t_k) dt_1 \dots dt_p \\ = \frac{1}{(2\pi)^p} \int_{-\infty}^{\infty} \dots \int_{-\infty}^{\infty} \exp \left\{ -i \sum_{k=1}^p t_k T_k + n B(\alpha_j) - n b(u_k + it_k) \right\} dt_1 \dots dt_p \end{aligned}$$

And from (3), the joint p.d.f. of the $\hat{\alpha}_j$'s is

$$\begin{aligned} \frac{n^p}{(2\pi)^p} \cdot \frac{\partial(\phi_1, \dots, \phi_p)}{\partial(\hat{\alpha}_1, \dots, \hat{\alpha}_p)} \int_{-\infty}^{\infty} \dots \int_{-\infty}^{\infty} \exp \\ \left\{ -ni \sum_{k=1}^p t_k \phi_k(\hat{\alpha}_j) + n B(\alpha_j) - n b(u_k + it_k) \right\} dt_1 \dots dt_p. \quad (8) \end{aligned}$$

3. *Explicit posterior probability distribution of the maximum likelihood estimates from a subsequent sample when an earlier sample is known*: We now proceed to obtain an explicit answer to the following frequently occurring problem. Given one sample of n observations x_1, x_2, \dots, x_n yielding the maximum likelihood* estimates $\hat{\alpha}_j$ of the parameters α_j , and no other information about the parameters; what is the probability that a second sample of n' observations $x'_1, x'_2, \dots, x'_{n'}$ will give the maximum likelihood estimates $\hat{\alpha}'_j$ in a particular region?

As an illustration, the problem considered by Jeffreys (1961, p. 142): Given a sample of n observations from the normal distribution (with unknown parameters) giving \bar{x} and s , being respectively the mean and the standard deviation of the sample; what is the probability that a subsequent sample of n' observations will give \bar{x}' and s' in a particular region?†

The problem is to evaluate

$$P \left(d \hat{\alpha}'_j \mid x_1, \dots, x_n, H \right) = P \left(d \hat{\alpha}'_j \mid \theta_1, H \right),$$

where θ_1 represents the first sample.

$$\begin{aligned} \text{Now } P \left(d \hat{\alpha}'_j \mid \theta_1, H \right) \\ &= \int_{(\alpha_j)} \dots \int P \left(d \alpha_j d \hat{\alpha}'_j \mid \theta_1, H \right) \text{ (the multiple integration being} \\ &\quad \text{with respect to the } \alpha_j), \\ &= \int_{(\alpha_j)} \dots \int P \left(d \alpha_j \mid \theta_1, H \right) P \left(d \hat{\alpha}'_j \mid \alpha_j, \theta_1, H \right) \\ &= \int_{(\alpha_j)} \dots \int P \left(d \alpha_j \mid \theta_1, H \right) P \left(d \hat{\alpha}'_j \mid \alpha_j, H \right). \end{aligned} \quad (1)$$

* In this problem in the theory of inverse probability, the term 'maximum likelihood' is introduced as a *derivative* principle, as an approximation to the principle of inverse probability. See Jeffreys (1961, p. 193).

† Fisher (1935) has considered the analogous problem in the fiducial theory: Given a sample of n observations from the normal distribution yielding the statistics \bar{x} and s , to find the fiducial frequency distribution of the statistics \bar{x}' and s' derived from a subsequent sample of n' observations.

Both factors in the integrand of (1) can be evaluated explicitly in terms of the α_j and $\hat{\alpha}'_j$. We have from (2.8),

$$P(d\hat{\alpha}'_j | \alpha_j, H) = \frac{n'^p}{(2\pi)^p} \cdot \frac{\partial(\phi_1, \dots, \phi_p)}{\partial(\hat{\alpha}'_1, \dots, \hat{\alpha}'_p)} d\hat{\alpha}'_1 \dots d\hat{\alpha}'_p \\ \times \int_{-\infty}^{\infty} \dots \int_{-\infty}^{\infty} \exp \left\{ -n' i \sum_{k=1}^p t_k \phi_k(\hat{\alpha}_j) + n' B(\alpha_j) - n' b(u_k + it_k) \right\} dt_1 \dots dt_p. \quad (2)$$

$P(d\alpha_j | \theta_1, H)$ can be obtained as follows.

$$P(dx_1 \dots dx_n | \alpha_j, H) = \exp \left\{ \sum_{k=1}^p u_k(\alpha_j) T_k + \sum_{l=1}^n A(x_l) + nB(\alpha_j) \right\} dx_1 \dots dx_n \\ = \exp \left\{ n \sum_{k=1}^p u_k \phi_k(\hat{\alpha}_j) + \sum_{l=1}^n A(x_l) + nB(\alpha_j) \right\} dx_1 \dots dx_n,$$

substituting for the T_k .

If $P(d\alpha_j | H) \propto \exp \{ \psi(\alpha_j) \} d\alpha_1 \dots d\alpha_p$, we have

$$P(d\alpha_j | \theta_1, H) \propto \exp \left\{ n \sum_{k=1}^p u_k \phi_k(\hat{\alpha}_j) + nB(\alpha_j) + \psi(\alpha_j) \right\} d\alpha_1 \dots d\alpha_p.$$

If the constant of proportionality is $C(\hat{\alpha}_j)$,

$$P(d\alpha_j | \theta_1, H) = \exp \left\{ n \sum_{k=1}^p u_k \phi_k(\hat{\alpha}_j) + nB(\alpha_j) + \psi(\alpha_j) + C(\hat{\alpha}_j) \right\} d\alpha_1 \dots d\alpha_p. \quad (3)$$

Finally substituting in (1) for $P(d\alpha_j | \theta_1, H)$ and $P(d\hat{\alpha}'_j | \alpha_j, H)$ from (2) and (3) respectively, we have the expression for $P(d\hat{\alpha}'_j | \theta_1, H)$ which comes out as a function of the $\hat{\alpha}_j$ and the $\hat{\alpha}'_j$ only.

The general problem considered in this section appears to have an analogue in the fiducial theory. The one-parameter problem has been referred to by Bartlett (1937).

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A Property of the Mean Deviation for the Pearson Type Discrete Distributions

A. H. Kamat

A Property of the Mean Deviation

Summary : A structural property relating the mean deviation to the variance and the value of the frequency function at the mean is established for the Pearson Type discrete distributions. Its generalisation is also briefly discussed.

1. An interesting structural property of some distributions involving the mean deviation is

$$\delta_1 = 2\mu_2 f(m) \quad (1)$$

where δ_1 = the mean deviation from the mean, μ_2 = variance, and $f(m)$ = the frequency function at m . Here $m = [\mu]$, the integral part in the mean μ of the distribution, for discrete distributions, and $m = \mu$ for continuous distributions. It seems this kind of relationship between the variance, the mean deviation and the frequency function had attracted the attention of mathematical statisticians during the twenties, e.g. Karl Pearson (1924), L. Von Bortkiewicz (1923), Gumbel (1927). After a lapse of almost thirty years interest in it was again revived when Johnson (quoted by Ramasubban, 1958) recently pointed it out. The property as stated in (1) holds for the Poisson distribution for all values of the mean, holds for the binomial and the negative binomial distributions when μ is an integer, and it also holds for the normal and Type III distributions among the continuous distributions. The property may be said to hold with a "correction factor" for the hypergeometric distribution, the hypergeometric waiting-time distribution and the runs distribution (the latter two as defined for instance in Wilks, 1962) when μ is an integer. (See Kamat, 1963). For other recent papers bearing on related results the reader is referred to Bardwell (1960), Bardwell and Crow (1964) and Kamat (1965a, 1965b, 1966a, 1966b, 1967).

2. In analogy with the Pearson class of continuous distributions it is natural to consider the class of discrete distributions (See for instance Katz, 1945 and 1963) defined by

$$\frac{f(x+1)}{f(x)} = \frac{P(x)}{Q(x)} \quad (2)$$

where $P(x)$ and $Q(x)$ are polynomials in x and where $f(x)$ is the frequency function of a discrete distribution defined on the consecutive integers $a \leq x \leq b$ and which satisfies the usual conditions : $f(x) > 0$ for $a \leq x \leq b$, and $\sum_a^b f(x) = 1$. In many of the

wellknown discrete distributions a is a zero or one and b may be finite or infinite. For the following discussion we shall restrict (2) to the case where $P(x)$ and $Q(x)$ are quadratic expressions in x . When the coefficients of the square terms in $P(x)$ and $Q(x)$ are equal (2) defines what may be called the Pearson class of discrete distributions, for in that case

$$\frac{f(x+1) - f(x)}{f(x)} = \frac{P(x) - Q(x)}{Q(x)} = \frac{L(x)}{Q(x)} \quad (3)$$

and $L(x)$ is then linear in x . (It is well known that Karl Pearson arrived at the famous Pearson differential equation for continuous distributions as the limit of a relation similar to (3) for the hypergeometric distribution and followed this approach for many years.) In the following paragraphs the quadratic expressions $P(x)$ and $Q(x)$ will be written for the sake of convenience, but without loss of generalisation, as

$$\begin{aligned} P(x) &\equiv a_2(x - \mu)^2 + a_1(x - \mu) + a_0 \\ Q(x) &\equiv b_2(x + 1 - \mu)^2 + b_1(x + 1 - \mu) + b_0 \end{aligned} \quad (4)$$

where μ is the mean of the distribution. Then the defining relation of the class becomes

$$\frac{f(x+1)}{f(x)} = \frac{a_2(x - \mu)^2 + a_1(x - \mu) + a_0}{b_2(x + 1 - \mu)^2 + b_1(x + 1 - \mu) + b_0} \quad (5)$$

with $f(x) > 0$ for $a \leq x \leq b$ and $\sum_a^b f(x) = 1$. It will also be

assumed that the usual boundary conditions are satisfied, that is, $Q(a-1) = 0$, $P(b) = 0$ when b is finite and when b is infinite $x^r f(x) \rightarrow 0$ as $x \rightarrow \infty$ for all r . (This corresponds to the condition of high-order contact of $f(x)$ with the x -axis in the continuous case).

3. A recurrence relation of moments can be easily found for the distribution defined by (5) as follows. We have

$$\sum_a^b (x-\mu)^r P(x) f(x) = \sum_{a-1}^{b-1} (x+1-\mu-1)^r Q(x) f(x+1) + (b-\mu)^r P(b) f(b) - (a-\mu-1)^r Q(a-1) f(a) \quad (6)$$

and since the last two terms on the right hand side vanish because of the boundary conditions this gives the relation

$$a_2 \mu_{r+2} + a_1 \mu_{r+1} + a_0 \mu_r = \sum_{i=0}^r (-1)^i (r_i) (b_2 \mu_{r+2-i} + b_1 \mu_{r+1-i} + b_0 \mu_{r-i}) \quad (7)$$

It can be verified that all the discrete distributions mentioned in para 1 belong to this class and therefore have recurrence relations of the type (7) for moments. Their incomplete moments (defined

by say $\sum_k^b (x-\mu)^r f(x)$) will also satisfy a recurrence relation

similar to (7) but it will contain an additional term corresponding to k . One interesting result is obtained from (7) by putting $r=0$. Since $\mu_0=1$, $\mu_1=0$, the relation (7) gives $a_2 \mu_2 + a_0 = b_2 \mu_2 + b_0$ and therefore $a_0 = b_0$ whenever $a_2 = b_2$ and vice versa. Now $a_2 = b_2$ defines the Pearson type discrete distributions and it can be verified that all the distributions mentioned in para 1 are Pearson type and that $a_0 = b_0$ for each one of them.

4. To obtain the relationship between the mean deviation δ_1 and other moments for this class of distributions let us first note

that, since $\sum_a^b (x-\mu) f(x) = 0$,

$$\delta_1 = \sum_a^b |x-\mu| f(x) = 2 \sum_{m+1}^b (x-\mu) f(x) \quad (8)$$

where $m = [\mu]$. Now consider the incomplete sum

$$\sum_{m+1}^b P(x) f(x) = \sum_m^{b-1} Q(x) f(x+1) - Q(m) f(m+1) + P(b) f(b).$$

Since the last term on the right vanishes because of the boundary conditions and since $Q(m) f(m+1) = P(m) f(m)$, we have

$$\sum_{m+1}^b P(x) f(x) = \sum_m^{b-1} Q(x) f(x+1) - P(m) f(m) \quad (9)$$

which, using (4) and (8), can be simplified to give

$$(b_1 - a_1) \delta_1 = 2(a_2(m-\mu)^2 + a_1(m-\mu) + a_0) f(m) + 2(a_2 - b_2) \sum_{m+1}^b (x-\mu)^2 f(x) + 2(a_0 - b_0) \sum_{m+1}^b f(x). \quad (10)$$

Now in the Pearson type discrete distributions $a_2 = b_2$ and $a_0 = b_0$. Hence the last two terms on the right will vanish and we have

$$\delta_1 = 2(c_2(m-\mu)^2 + c_1(m-\mu) + c_0) f(m) \quad (11)$$

where $c_2 = a_2/(b_1 - a_1)$, $c_1 = a_1/(b_1 - a_1)$ and $c_0 = a_0/(b_1 - a_1)$. This can be expressed in the form of a generalisation of (1) as follows. Putting $r=1$ in (7) and noting that $\mu_0=1$, $\mu_1=0$, $a_2=b_2$, $a_0=b_0$ we have $(b_1 - a_1 - b_2) \mu_2 = b_0 - a_0$. Hence (11) can be rewritten as

$$\delta_1 = 2(d_2(m-\mu)^2 + d_1(m-\mu) + d_0) \mu_2 f(m) \quad (12)$$

where d_2, d_1, d_0 are obtained respectively from c_2, c_1, c_0 by multiplying them by $(b_1 - a_1 - b_2)/a_0$. When μ is an integer this becomes

$$\delta_1 = 2 d_0 \mu_2 f(m) = 2 \left(1 - \frac{b_2}{b_1 - a_1}\right) \mu_2 f(m). \quad (13)$$

We may therefore say that for the Pearson type discrete distributions defined in para 2 the generalisation of the property (1) is given by (12) and that when μ is an integer the property holds with the "correction factor" d_0 . Further, $d_0 = 1$ if, and only if, $b_2 = 0$, a conclusion which is similar to what was obtained for the Pearson type continuous distributions (Kamat, 1966b).

5. From the recurrence relations (7) putting $r=0, 1, 2, 3, 4, 5$ and using $a_2 = b_2$, $a_0 = b_0$ and $\mu_0=1$, $\mu_1=0$, we can express the a and b coefficients in terms of μ_2, μ_3, μ_4 . Hence c_2, c_1, c_0 of (11) can be expressed in terms of μ_2, μ_3, μ_4 . Thus we obtain

$$\begin{aligned} c_2 &= \frac{2 \mu_4 \mu_2 - 3 \mu_3^2 - 6 \mu_2^3 + \mu_2^2}{6 (\mu_4 \mu_2 - \mu_3^2 - \mu_2^3)} \\ c_1 &= \frac{\mu_3 (\mu_4 + 3 \mu_2^2 - \mu_2)}{6 (\mu_4 \mu_2 - \mu_3^2 - \mu_2^3)} - \frac{1}{2} \\ c_0 &= (1 - c_2) \mu_2 \end{aligned} \quad (14)$$

These values are identical with those obtained for similar coefficients for the class of distributions considered in Kamat (1965a). It now appears that the class defined there is included in the Pearson type discrete distributions defined here with $a_2 = b_2$ (and therefore $a_0 = b_0$ because of the boundary conditions). We

did not realise this until we examined the Pearson discrete class. When $c_2 = 0$, that is, when $a_2 = 0$, we have $c_0 = \mu_2$ and then the property (1) holds exactly for integral values of μ . Otherwise it holds with the "correction factor" d_0 or $1 - c_2$ for integral μ .

6. The subclass of the distributions defined by (5) when $a_2 = b_2 = 0$, that is, when $P(x)$ and $Q(x)$ are linear, is interesting. Among the discrete distributions mentioned in para 1 the binomial, the negative binomial and Poisson distributions belong to this subclass while the other three do not belong to it. For this subclass the recurrence relation (7) for moments reduces to

$$a_1 \mu_{r+1} + a_0 \mu_r = \sum_{i=0}^r (-1)^i (r_i) (b_1 \mu_{r+1-i} + b_0 \mu_{r-i}) \quad (15)$$

Since as observed above, $d_0 = 1$ when $b_2 = 0$, the relation (12) for this subclass reduces to

$$\delta_1 = 2 (d_1 (m - \mu) + 1) \mu_2 f(m). \quad (16)$$

The number of a and b constants is now reduced and using (15) it can be shown that

$$d_1 = \frac{a_1}{b_0} = \frac{\mu_3 - \mu_2}{2 \mu_2^2}. \quad (17)$$

If in addition $a_1 = b_1 = 0$, (5) yields only two distributions: (i) When $a_0/b_0 < 1$ we have the geometric distribution; this can be looked upon as a particular case of the negative binomial which is covered by (16). When $a_0/b_0 = 1$, we have the uniform distribution which does not satisfy the boundary conditions of para 3, and (15) and (16) do not apply.

7. Finally we would like to make two observations. First, the logarithmic series distribution has a recurrence relation of the type (5) for its frequency function but it does not satisfy the boundary condition at the lower end. It has not been so far possible to obtain a relationship of the type (12) or (16) for this distribution (see Kamat, 1963). Secondly, it appears from (10) that it may not in general be possible to obtain a relationship between δ_1 , μ_2 and $f(m)$ of the type (12) or (16) when a_2 and b_2 are not equal, that is when the distribution is not Pearson type. On the other hand, when $P(x)$ and $Q(x)$ of (5) are polynomials of higher degree than the second with coefficients a_s , b_s ($s=0, 1, 2, \dots, n$) and if $a_s = b_s$ for $s=2, 3, \dots, n$, then it should always be possible to have a generalization of (11) of the form

$$\delta_1 = 2 f(m) \sum_{s=0}^n c_s (m - \mu)^s$$

where $c_s = a_s / (b_1 - a_1)$. And it should also be possible to express c_s in terms of moments of the distribution using the corresponding generalisation of (7) viz.

$$\sum_{s=0}^n a_s \mu_{r+s} = \sum_{i=0}^r (-1)^i (r_i) \left(\sum_{s=0}^n b_s \mu_{r+s-i} \right) \quad (19)$$

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Formula for Chromosome Mapping

Since T. H. Morgan and his colleagues in U.S.A. propounded the Chromosome Theory of Heredity, comprising the linear arrangement of genes in chromosomes and their recombination through the phenomenon of crossing-over of homologues during meiosis, chromosome-mapping has been an active pursuit among geneticists for an understanding of the serial order of genes and their spatial relations. The interest in it has widened in recent times on account of the findings such as: (i) linkage regulates the gene-flow between and within plant populations to meet the conflicting needs of adaptation and adaptability (Thoday, 1958); (ii) a balance exists in nature between the two constituents of the 'breeding system', viz., (a) the amount of recombination through crossing-over and (b) that resulting from genotypic differences between gametes uniting during fertilisation (Lewis, 1966); and (iii) even polygenes by which a number of economic characters are governed can be mapped (Thoday, 1961).

Morgan visualised that the frequency of recombination of any two genes was, to some extent, proportional to the distance between them on the chromosome. As the recombination fraction was the mathematical expectation of cross-overs occurring in the interval, it was expected that the cross-over value of a containing segment would be equal to the sum of those of the contained segments. This expectation was not fulfilled in the case of long (contained) segments (of more than about 10 c.o.). The incongruity was recognized as due to the 'coincidence' resulting from multiple cross-overs which were likely to occur in long segments. Therefore, if recombination fraction Y was to be an index of the linear interval or 'Map Distance' X on the chromosome, it was essential to think of a Mapping Function of Y

which would make map distances additive irrespective of their magnitudes and throughout the length of the chromosome. On the assumption of randomness of crossing over and accounting for 'coincidence', Trow devised in 1913 a formula,

$$Y_{1+2} = Y_1 + Y_2 - 2Y_1Y_2$$

'The formula is universally true for all pairs of contiguous segments and states the addition theorem for recombination as a function of interval.'

However, a second cause of disturbance in additivity, viz., the phenomenon of 'interference' was brought to light by Muller in 1916. By interference it is meant that the occurrence of one cross-over tends to hinder the occurrence of another in its neighbourhood, due to which the probability of two cross-overs occurring simultaneously in a segment is less than the product of probabilities of their separate occurrence.

In order to provide a completely additive metric for intervals, which could more appropriately be expressed in geometrical units, Haldane (1919) converted Trow's formula into a Mapping Function,

$$Y = m(X) = \frac{1}{2}(1 - e^{-2x})$$

Further, to account also for 'interference' he introduced a constant C_0 as the 'marginal coincidence', an upper limit of coincidence, 'C', and expressed the mapping functions for segments of different sizes in terms of Y the recombination fraction and X the map distance as follows:—

- (i) For small X , $X = Y$
- (ii) For large X , (where $C_0 \rightarrow 1$)
 $X = -\frac{1}{2} \log_e (1 - 2Y)$
 $Y = \frac{1}{2} (1 - e^{-2x})$

- (iii) For all intervals,

$$X = -\frac{1}{2C_0} \log_e (1 - 2C_0Y)$$

$$Y = \frac{1 - e^{-2C_0x}}{2C_0}$$

Kosambi (1944) noted that the constant C_0 for marginal coincidence included in Haldane's equations introduced unnecessary complications without any special advantage. As there is nothing like an intrinsic unit of map length which is only an imaginary metric (unrelated to either the physical or cytological length of the chromosome), the primary re-

quirement in the mapping function is consistency, together with simplicity if possible, and "that formula is the most suitable for which distances are additive within the limits of significance". On the basis of the above arguments and assuming C_0 to depend in some way on X and to increase steadily, Kosambi derived a very valuable mapping function:

$$X = \frac{1}{2} \tanh^{-1} 2Y = \frac{1}{4} \log_e \left(\frac{1 + 2Y}{1 - 2Y} \right)$$

and

$$Y = \frac{1}{2} \tanh 2X$$

By using the function, map length (in centimorgans) can be obtained either by referring to tables of logarithms or to the table of r to Z transformation in Fisher and Yates Statistical Tables.

The special advantage in Kosambi's mapping function is that the corresponding addition theorem for Y is very simple, being,

$$Y_{1+2} = \frac{Y_1 + Y_2}{1 + 4 Y_1 Y_2}$$

The fit of Kosambi's formula to recombination data in any particular case can be tested by working out what Owen (1950) calls the *Kosambi Coefficient* K , given by

$$K = \frac{Y_1 + Y_2 - Y_{1+2}}{4 Y_1 Y_2 Y_{1+2}}$$

Whenever the Kosambi formula is satisfied, K is equal to unity; when less than unity, interference is in excess of the Kosambi level and when more than unity, it is less than that of the Kosambi level. As in the case of Haldane's mapping function, there is an assumption even in Kosambi's formula of a uniform intensity of interference over the entire length of the chromosome.

Kosambi's formula, which is empirical, was tested by this author, soon after its publication, in two different cases, viz., (i) on the three-point segregation data of Punnet on sweet pea (Bhat, 1947) and (ii) on the four-point data of N. E. Jodon on rice (Bhat, 1950). In both the cases, the formula gave good fit with high precision; moreover, in the latter case it became possible to clear Jodon's doubt about the factor, *Gu* (glutinous grain) and *Cl* (floret arrangement) being in the same linkage group since all the four factors including the above two could

be coherently mapped on an additive basis in the same chromosome. Later, Bhat and Argikar (1951) found the formula agreeing very well also in a three-point test in *Cicer arietinum*.

Of far greater value is the fact that the formula has been found useful in the treatment of data suggestive of more than 50 per cent crossing-over, which has been observed since long in both plants and animals. The unusual occurrence has been found to be caused (i) by chromatid interference and (ii) chiasma interference. Chromatid interference is the result of an abnormal exchange taking place between sister strands of the self-borne chromosome, but, as it is a rare event, it is not thought to deserve separate consideration in the mathematical treatment of the 'interference' problem. But, chiasma interference, i.e., the interference occurring within a strand considerably affects the crossing-over in it, though theoretically it is not imperative that the highest limit to the recombination fraction should be 50 per cent.

Jennings and Winge indicated, subject to certain provisos, the possibilities of recombination in excess of 50 per cent between moderately remote genes. From analysis of both genetical and cytological data, Mather has formulated in 1936 a theory of serial formation of chiasmata embodying the following points:

- 1) The two arms of a bivalent are independent, the centromere operating as an insulator suppressing all or nearly all interference between them.
- 2) Chiasma formation proceeds on either side of the centromere according to a serial process starting from a certain mean cytological distance from the centromere which Mather calls 'differential distance'.
- 3) The distance at which the first cross-over takes place is correlated with the length of the arm and would therefore be different for chromosomes of different lengths.
- 4) Mather calls the cross-over intervals beyond the first chiasma by the name, 'interference distance' and has found them to be more or less uniform.

On the basis of Mather's theory, Owen (1950) points out the possibility that 'for sufficiently intense interference on long enough arms, the recombination fraction may be expected to show oscillations and have some maxima and minima on either

side of the 50 per cent level.' Further, on mathematically examining the implications of the Kosambi formula, he finds that, in the case of short and medium long arms, "at the Kosambi level of interference, recombinations between the terminus and an interior locus may be as great as 60 per cent, and, between the centromere and some loci as great as 55 per cent".

It is interesting to point out that the Kosambi formula provided R. A. Fisher a model for selecting the function,

$$\frac{d}{du} \left(-\operatorname{Sech} \frac{\pi u}{2} \right), \text{ for a fairly successful treatment of the sex}$$

chromosome data in the house mouse which involved recombinations in excess of 50 per cent. By applying the function, Fisher *et al* (1947) obtained recombinations of 56.07 per cent between *Sex* and *Wv₂*, 56.73 per cent between *Sex* and *Sh₂*, and 31.06 per cent between *Wv₂* and *Sh₂*, all with S.E. of the order of only 2.3 per cent, and constructed a coherently additive map of the sex chromosome.

In conclusion it may be stated that the Kosambi formula which, though 'largely an intelligent empiricism', is the only one so far which gives satisfactory additive estimates of map lengths irrespective of the kinds of organisms and the lengths of their chromosomes on which recombination data are gathered. Its logical status, as described by Owen (1950) is 'of an intelligent and appropriate computational device, by which the first steps in the successive reduction of data to the map-form may be short-circuited'. The formula, spotlights Kosambi as 'a type of the wise who soar but never roam'.

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11 On the Quantitative and Qualitative Definitions of the Alpha-Phonoid*

C. R. Sankaran

Introduction

Our attempt towards defining the ultimate 'Unit' of Speech (Alpha-Phonoid) has now led us to the problem of building up a logical calculus of transformations or meta-rules,¹ bridging with the observation records i.e. the "pointer-readings".²

Our task, undoubtedly, is quite arduous. The continuum due to Veronese surrenders the limit element of the 'fundamental series' of Cantor and the mean value theorem.³ We must join that band of workers who try to build up a newer Mathematical Analysis. Fresh postulates and a new logical calculus have yet to be built up in these investigations towards the search of the ultimate 'Unit' of Speech (the Alpha-Phonoid).

I

I am giving below a theoretical picture of the assumptions, conditions and the purpose behind the investigations in the wake of an attempt to define Alpha-Phonoid quantitatively.

* Presented to the Physiology Section of the 56th Session of the Indian Science Congress Association, Powai, Bombay, 1969.

1. Cf. M. Remmel, "On the Alpha-Phonoid (Alpha-Phoneme) Theory," *Terminologia Indica* 1 : pp. 61-62, Tartu 1967.
2. I refer the interested readers of this note to my, Towards my scientific autobiographical notes, *Orientalistikakabineti I Aastakollokviumi Materjalid*. Tartu 1968, pp. 37-39, for a suggested picture of the Alpha-Phonoid concept within the framework of modern "Motor Phonetics". See also G. Werner, "An examination of Axiomatization and Information Theory Application in Neurophysiology" (*Journal of Scientific and Industrial Research* 1959, vol. 18 A, No. 10, p. 467) for the relation between the blanket statement and "observational records".
3. See C. R. Sankaran, *Process of Speech*, *DCMS* 27, 1963, p. 30 (*DCMS* = Deccan College Monograph Series).

Assumptions

1. A change in the time-constant T^1 is necessary for any discrimination (of duration, frequency or intensity). This has to be demonstrated both experimentally and mathematically.
2. The simultaneous presence of such a change in the time-constant of the inner processes and a change in duration, frequency or intensity in the outer processes (respectively in the neurophysiological and acoustical media)⁵ is the basis for the inductive postulation of the existence of the Continuum due to Veronese in the perceptual processes (apart from the deductive postulation of such a continuum in the wake of the alpha-phoneme theory).

Conditions

1. The Veronesean condition of a non-Archimedean order should be fulfilled.
2. Duration, frequency and intensity should be reducible as a
4. Cf. Mol and Uhlenbeck, "The analyses of the Phoneme in Distinctive features and the process of Hearing", *Lingua* 4, (1954-55), pp. 167-193.
5. Vide our previous discussion on the motivational and activational levels respectively in speech-continuum and utterance-continuum. C. R. Sankaran and N. K. Patil, "Alpha-Phonoid and Alpha-Phoneme", *Phonetica* 17: 15-23 (1967).

Our 'motivational' level corresponds to L. S. Vygotski's hypothesis that the "inner speech, abbreviated in its structure and predicative in its function, is an important link between the initial thought and the final extended verbal proposition".

Vygotski, L. S.: *Thought and Language*, M.I.T. Press, Cambridge, Mass, 1962, p. 149.

See also, Luria, A. R. and Tsvetkova, L. S.: "The Mechanism of 'Dynamic Aphasia'", *Foundations of Language*, 4 (1968), pp. 299-300.

We may here remember too, that Eric H. Leuneberg has observed that language readiness is a state of latent language structure and language unfolding is a process of actualisation transforming this into a realised structure.

Compare Eric H. Leuneberg, *Biological Foundations of Language* with appendices by Noam Chomsky and Otto Marx. John Wiley and Sons, Inc. New York, London, Sydney, 1967.

A critical review of this work by Sankaran, C. R. and Krishnamurthy, K. H. appeared in the *Bulletin of Deccan College Research Institute*.

We draw also the attention of the interested readers to the paper "Continuity in Speech Perception", by Sankaran, C. R. and Patil, N. K., presented for the Inter-disciplinary Seminar on Linguistics and other Sciences, 1970 at Annamalai University, Tamil Nadu.

result of their bi-unique correspondences, through transformation equations in terms of T_t , T_a and T_f .

3. The time-constant T should be taken as being equivalent to an 'observer' and if descriptions of speech or any vibration phenomena are made in terms of times t ($= T_t + T_a\eta + T_f\zeta \dots$) and T by an equation, such an equation should not differ in form from a description of the same phenomenon in terms of t' and T' .
4. It should be possible to establish transformational equations between, t , T and t' , T' .
5. There will thus be a quantity X which will be an invariant for all observers T , T' , etc.
6. Such a derivation should ultimately absorb in itself the essentials of the continuum due to Veronese, Robb's geometry of time and Milne's relativity and should be equally applicable to intermittent and continuous phenomena.⁶

Purpose

The purpose of the study is to seek the quantity X (Condition 5 above) through such a logical calculus; a quantity which is representative of the Alpha-Phonoid.

Thus far is the present attempt towards the theoretical formulation in regard to a quantitative definition of the Alpha-Phonoid.

II

Now I proceed to give also a critique of my qualitative definition of the Alpha-Phonoid.⁷ The Alpha-Phonoid has been qualitatively defined as "the minimum duration of a 'Unit information cell' in the physical stimulus as well as in the neurophysiological and psychological responses; the minimum common duration of all these three will then serve as the key 'interval' for the basic representation of Speech-Structure (the Alpha-Phonoid)."⁸

6. Cf. C. R. Sankaran, "Phonemics of old Tamil", *DCMS* 7, 1951, pp. 2, 9, 28, 29, 30 and 35.
7. I am indebted to Bjorn Merker of the Lifwynn Foundation, Connecticut, U.S.A. for this critique contained in his letter to me dated May 22, 1968.
8. Cf. i. C. R. Sankaran and L. H. Strong, "A Critique of Experimental Techniques, Methods and Analyses in the study of structure in

The conceptual and technical difficulties facing an attempt to determine the "ultimate Unit of Speech" as the minimum common duration of the physical stimulus, neurophysiological and psychological components of the total event seem formidable in the present state of the brain sciences, especially as they bear on such high level functions as human speech. The lack of functional-structural clarity in this field is reflected in the sporadic and fragmentary attempts at studying the speech process in terms of brain function.

The following are some attempts in recent times :

So called "command potentials" (averaged evoked potentials of surface Electro-Encephalograms i.e. EEG preceding various voluntary activities) was shown to differ in shape for phonemes O, T and P (but not for numerals 2 and 10 or for the words "Yes" and "No") when recorded over the left temporal speech area.⁹

The peripheral nervous system involvement in the speech process (the orienting reflex, recorded by a new plethysmographic technique distinguishing orienting from defensive reaction by a vaso-motor criterion) led two Russian workers to postulate a semantic model of word nuclei surrounded by a semantic field of words linked to the nucleus by experimental meaning relations rather than logical content.¹⁰

Analysing human behaviour, including verbal behaviour, from sound motion pictures allowed two American workers to study "Motor Phonetics" with the help of a "basic form of 'unit-in-change' or 'process unit'" by which they were able to describe the "ongoing flow of 'moments-of-sustaining-together' of the body parts" in continual sequences of change.¹¹

Speech," Deccan College Building Centenary and Silver Jubilee Series 40 : Poona 1965, pp. 49-50.

ii. C. R. Sankaran, "Determination of the Ultimate 'Unit' of Speech," *Phonetica* 14 : 85 (1966).

iii. J. Knobloch, *Das Sprachwissenschaftliches Wörterbuch*, Universitätsverlag, Carl Winter, Heidelberg, 1961, p. 100.

See also the paper on the same subject of Sankaran, C. R. in *Phonetica*, Vol. 20, Nos. 2-4 (1969).

9. Edward W. P. Schafer, "Cortical Activity Preceding Speech ; Semantic Specificity", *Nature*, 1967, Vol. 216, pp. 1338-1339.
10. A. R. Luria and O. S. Vinogradova, "An Objective Investigation of the Dynamics of Semantic Systems", *British Journal of Psychology*, 1959, Vol. 50, No. 2.
11. W. S. Condon and W. D. Ogston, "A Segmentation of Behavior", *Journal of Psychiatric Research*, 1967, Vol. 5, pp. 221-235.

These are the widely different techniques and instrumental approaches that are being employed, as Björn Merker rightly observes, in the objectification of the semantic process and these varied techniques and experimental investigations might be relevant to the investigation of the Alpha-Phonoid which is qualitatively defined as the minimum common duration of the physical stimulus as well as the neurophysiological and psychological response-components of a total event.

Björn Merker remarks that the abovementioned objectifications of the semantic process are the surface or overt events of the speech-process while the definition of the Alpha-Phonoid goes further, as indeed one must, in order to distinguish human speech from animal calls so as to include the psychological component at high levels of abstraction and integration. In terms of the brain this points to the convergent structures of the limbic system, which is subcortical and accessible only by implanted depth electrodes. R. G. Heath has recorded electrical activity in limbic structures in humans directly correlated with emotional thought and recall, but intracranial recording is not a generally applicable technique in humans.¹²

These technical problems are further complicated by the theoretical consideration that the information content of a stimulus event cannot be defined independently of the nature of the information processing and storage capacity, which in man is shaped by accumulating ontogenetic experience to an unusual degree, resulting in great individual and temporal variation.

The very magnitude of this problem makes it the more challenging a task and, therefore, the theoretical formulation of the Alpha-Phonoid seems to provide, as Björn Merker thinks, a provocative perspective within which one may strive to approach a solution. The results of any deep experimental investigation within this perspective might find too an application within phylobiology when that baby science, to quote once again Björn Merker, "reaches the maturity of Speech and concrete manipulations".

12. H. Lesse, R. G. Heath, W. A. Mickle, R. R. Monroe and W. H. Miller, "Rhinencephalic Activity during Thought", *Journal of Nervous and Mental Disease*, 1955, 122, pp. 433-440.

Part III

Biographical and Other Reminiscences and Tributes

I Prof. D. D. Kosambi :

A Brief Chronology of Major Events

July 31, 1907	Born at Kosben, Goa.
1912-1918	Early education in New English School, Poona.
1918-1925	Studied at Cambridge Grammar School and Latin High School, Cambridge, Mass., U.S.A.
1925-1929	Studied at Harvard University. Graduated with S.B. ' <i>Summa cum Laude</i> ' and ' <i>Phi-Beta-Kappa</i> ' membership.
1929-1937	On the staff of Benares Hindu University.
1930	First published paper on scientific subject "Processions of an Elliptical Orbit" in <i>Indian Journal of Physics</i> .
May 7, 1931	Married Nalini Madgavkar, Bombay.
1931-1932	On the Staff of Aligarh Muslim University.
1932	Papers first published in French and German.
1933	On the staff of Fergusson College, Poona.
November 10, 1935	First daughter born (now Mrs. Sarkar in Sweden).
April 24, 1939	Second daughter (Meera) born. She has had a very brilliant academic career, both in India and in Sweden.

A Rough Diamond

1947	Joined the Tata Institute of Fundamental Research (Mathematics Department), Bombay.
1956	<i>Introduction to the Study of Indian History</i> published by Popular Book Depot, Bombay.
1957	<i>Exasperating Essays</i> published by People's Book House, Poona.
August 26, 1960	Grand-daughter (Nandita) was born.
1962	<i>Myth and Reality : Studies in the Formation of Indian Culture</i> published by Popular Prakashan, Bombay.
1962	Retired from the Tata Institute of Fundamental Research, Bombay.
1965	<i>The Culture and Civilisation of Ancient India in Historical Outline</i> published by Routledge & Kegan Paul, London.
1965	Scientist Emeritus conferred by Council of Scientific and Industrial Research, New Delhi.
June 29, 1966	Passed away in sleep at Poona.

Professor Damodar Dharmanand Kosambi, died in his sleep in his Poona home on June 29, 1966, just a month or so before he would have been 59 years old on 31 July. That is how a man like him deserved to die, without pain and suffering, for he had known both in his lifetime and stood for their elimination, not infliction.

He inherited his passion for learning and humanism from his father, Professor Dharmanand Kosambi, a venerable scholar and research worker, who devoted his life to the study of the teachings and philosophy of the Buddha, India's first gift to the world, and taught at Harvard University in the U.S.A.—quite an achievement for both teacher and University in those days.

This explains why the younger Kosambi, known as 'Baba' to his friends, went to the U.S.A. at an early age, joined the Cambridge Grammar School, later attended the Latin High School, and finally Harvard University, from where he graduated in 1929 with S.B., "Summa Cum Laude", also winning a "Phi-Beta-Kappa" membership.

Baba had a curious attitude about pictures of himself and would not let them get around. He felt so strongly about this that he would not give a photograph of his to his class album. He remarked to his friend at one time that he had two counts against himself, a brown skin and a "Jewish" nose. His friends suspected that he was so angry at U.S. prejudices along these two lines, that he would not let U.S. students get his pictures in an album.

His versatile and enquiring mind started to reveal itself early. For some reason or other he spent about a year or so in India before entering Harvard, studying differential equations. As a hobby, Baba worked out the usual problems of ballistics, tracing

the path of a bullet not only as influenced by gravity but also with elaborate corrections for air resistance—this before his freshman year. He spent a considerable time firing a rifle and checking up on his equations. At Harvard he registered for sophomore physics and went into the laboratory. One of the first experiments required of him was to fire a bullet into a ballistic pendulum and to work out the velocity of the bullet from the pendulum swing. The young laboratory assistant came round with the gratuitous advice that “you should use conservation of energy, equating the initial kinetic energy of the bullet with the sum of the change of potential energy of the pendulum and bullet”. Baba was horrified and politely remarked that he was afraid he had misunderstood him and would he mind repeating it. He did and Baba said “Oh” and walked out of the Lab, thereby dropping the course (and getting an F for it). He had felt he had nothing to learn from such a fellow. He was the only student ever to make both an F and a “Summa Cum Laude”.

One spring after the grades came out, Baba dropped into a friend's room, quite upset. He had had a letter from his father saying that he was obviously wasting his time or else he would have done better than 3 A's and a B, and that, if he was not going to work, he had better come back to India. He thought he would take a summer school course and “show him”. A course in Italian was considered worth while. As usual in a first course, the instructor assigned a choice of reading three out of five student-use shortened versions of full books. Baba hunted up the five full Italian editions and also Mussolini's Autobiography, all of which he read through. At the end of the course he received a note from the instructor, giving him an A plus, with the remark that it was the first time he had ever found it necessary to give such a grade. The note was duly relayed to his father in India.

At one time a friend of Baba's was taking a course in Quantum Theory, and it came to the point of derivation of Bohr's spectrum rules. The instructor assigned an article explaining Einstein's derivation. He looked up Einstein's paper in the German original and found it very clear, although the “explanation” of his article by another writer, was confusing. He remarked to Baba about Einstein's article and was astonished to find that although he was a student of mathematics (not physics), he could remember details from Einstein's paper and knew of subsequent more elaborate papers.

Baba's ideal in the mathematics department was George

Birkhoff (not the son Garett). As an undergraduate he took one or more “Research” seminars—private courses from Birkhoff, probably on the M-body problems. His forté, though, pointing towards later accomplishments, lay in his remarkable diversity—his father backed him up in this, saying his speciality was all right, but that if he wanted to go afield, by all means to do so. Hence, we suppose, his later interest in Indology, etc. Baba and Norbert Wiener were of course friends of very long standing, and the two of them were the most versatile persons ever to be encountered.

On the personal side, during his student days, Baba was much the same as in later years, full of fun and humour. He was particularly loyal to his old Cambridge Latin High School friends and those around the Cambridge Central Square YMCA. He frequently ate supper in the YMCA Cafeteria and in a little cheap restaurant at Central Square rather than around Harvard Square. His friend and he often went to a movie at Durrell-Hall, the YMCA movie theatre, where they liked the relaxation of the sillier “Westerns”, with the old piano player who was not always synchronised. Baba also went swimming at the YMCA and worked out in the Gymnasium. In later years when he revisited the U.S.A. to look into computer problems Baba dropped in on the YMCA, and his old friends were so tickled to see him that they made up a party, and took him to supper and to the “Icecapades” at the “Boston Garden”.

Baba used to room with his father in a beautiful room on the first floor of a rooming house at 10-Trowbridge Street. When his father returned to India from teaching at Harvard, Baba moved up to one of four unheated rooms on the top floor at \$ 4/- per week, about the cheapest in Cambridge. When his friend met Baba again at South Station after he had been many years in India, he was afraid to see him changed and older. Instead he arrived with a huge knapsack on his back, vigorous and fun-loving as ever.

Recalling the story about Italian studies, in those days during the “Fall” season a student was in his room one night after his Italian Summer course. Apparently in the second half of the summer Baba read Dante by himself. Baba was asked who the student was, and he answered—“Oh, he was a young Italian student and I was giving him advice on his Doctorate thesis, on Dante”. This was sophomoric, his friend thought, but he had confidence that it was good advice.

Baba specialised in pure and applied mathematics (Tensor Analysis, Probability), theoretical and applied statistics (includ-

ing work on the Indian population problem), and in these his reputation was unchallenged. He won the first award of the Ramanujan Memorial Prize in 1934 and a special Bhabha Prize in 1947. Baba was UNESCO Fellow to the U.S.A. and the U.K. for electronic calculating machine research in 1948-49, Visiting Professor (Geometry) at Chicago in the winter term of 1949, and guest of the Institute for Advanced Study, Princeton, in 1949, where the main work covered several technical discussions with Einstein on his unified field theory and with O. Veblen on tensor analysis. Many invitations from abroad followed, but not all could be accepted. Among those accepted, however, was a personal invitation from the Soviet Academy of Sciences, in 1955, to lecture, and to attend their first conference for the peaceful uses of atomic energy, and a personal invitation from the Academia Sinica, Peking, to suggest statistical methods for the forecasting of Chinese food-crops, and quality control in industry (these suggestions were discussed separately by Kuo Mo-Jo and Chou En-lai with Baba in person, and approved, but the results are not known).

Sanskrit text study by Baba ranged from the search for manuscripts to publication. Chief among them were: A. Principal editions of Bhartṛhari's *Śatakas*, admitted to be the best of their sort, and as having added considerably to methods of Indian textual criticism. B. A recent edition published by the Harvard Oriental Series, of the oldest discoverable Sanskrit anthology, the *Subhāṣitaratnakośa* of Vidyākara. Baba was engaged in a standard translation of the *Arthaśāstra*, on which his studies showed him to be the leading authority.

Indian history and culture claimed his thorough attention too. Baba's *Introduction to the Study of Indian History* received lengthy and favourable reviews abroad in the *Journal of the American Oriental Society* and the *Bulletin of the School of Oriental and African Studies* (of the University of London), not to mention others, and is supposed to mark a new stage in Indian historiography. To write it, he did pioneer work in archaeology and ethnography, showing that written sources would not suffice. He did not conceal his reliance on dialectical materialism as a methodology of study and interpretation, though on many issues he widely differed from "official Marxists", as he used to call them — whether of the Russian, Chinese or indigenous variety.

As an Indologist, Baba was invited by the University of London (under the sponsorship of the British Council and the London School of Oriental Studies), and had a special invitation to attend the next International Congress of Orientalists. These

were unsolicited, and his research bibliography listed over a hundred titles of original papers.

Baba guided the archaeological club of the National Defence Academy at Khadakvasla at the request of its first Commandant, Major-General E. B. Habibullah, who said later that he had taught them all how to do field work, to observe how to appreciate the common people's way of life. The cadets would be better citizens and officers for it, and would be closer to the people.

The investigation of trade-routes for the history book led Baba to suggest to the Government of the then Bombay State that the expensive funicular proposed for Nanaghat would only be a useless bottleneck. A motorable all-weather road could be made quite economically down the next pass to the north. This would have given the central link in a system of three trunk roads that would have developed the entire Maharashtra-Vidarbha section of Bombay State. The saving would have been at least Rs. 15 lakhs, not to speak of the profit, stimulus to trade, and communications, etc. The suggestion was not based on book-reading and maps alone but on extensive (and expensive) trips on foot, by jeep, car, or through the wildest country.

By concentrating the anti-typhoid work about three weeks before the onset of the monsoon, it was estimated that about 500 lives could be saved annually in Bombay city alone, as followed from Baba's work on the seasonal death-rate. The City medical section took this up immediately.

The construction of dams was being undertaken on arbitrary principles. If too large, the cost rises; if too small, there is every chance of the supply failing every few years. Statistical methods originally suggested by Baba to competent engineers have now been adopted by the 5-year plan committee as the basis for location and size of dams. Earlier, there had been expensive arguments (without valid basis on either side) on this question.

In the years just before his death, as Emeritus Scientist of the Council of Scientific and Industrial Research, Baba was engaged in extensive field work which led to his rediscovery of neolithic routes, Buddhist caves, and old inscriptions. He was hoping it would lead to further discoveries of manuscripts in Nepal, Rajputana and generally in inaccessible parts of India. He was anxious to see that the search for Sanskrit manuscripts, which was only being talked about, was undertaken very soon, before the material was destroyed or damaged beyond recovery.

Baba served at the Tata Institute of Fundamental Research as

Senior Mathematician from its inception in 1945-46 to 1962. When his service came to an end, he could have emigrated but disliked the prospect as he believed that his roots were in India, and that he could not work out Sanskrit text-study and Indian history as well elsewhere. He was accused of neglecting mathematics and of being an amateur Indologist, but that was not the opinion of world experts. Just before his death he was said to have completed and posted to his publishers the manuscript of his last work on Prime Numbers, on which he had been working for several years and which could well have led to breaking new ground in Pure Mathematics. A versatile linguist, Baba knew several Indian and European languages, had a fine library which needs to be protected and utilised, and a good collection of microliths and megaliths. He loved his dog Cātyā and later Bonzo and they went out for long walks together.

Published volumes of Baba's works include *Exasperating Essays, Myth and Reality* in which he deromanticised the Bhagavad-Gītā, and *The Culture and Civilisation of Ancient India in Historical Outline*. But what was he like as a man?

He could be difficult, arrogant, sharp, blunt, aggressive, uncompromising, but also very gentle, with a breezy personality. He applied exacting standards to himself and wanted to extend it to others, but this does not work. There was no false modesty about him, yet he did not lack the essence of true humility. He believed in calling a spade a spade, which often got him into plenty of trouble, but he was not vindictive. He was relentless in his search for truth and no armchair scholar, as he believed in hard field work, which meant trudging long hours under the blazing sun, looking for archaeological finds or primitive survivals, to fill the gaps in recorded history.

Although the window of his mind was wide open, he could be dogmatic and intolerant, sometimes one-sided, with a tendency to put ideas into water-tight compartments. But he had an encyclopaedic, precise mind, with a flair for original research, which kept extending the boundaries of knowledge. Hence the importance he attached to methodology, yet at times the methodology tended to become an end rather than the means.

Baba did not know how to relax, he was a tireless worker, talker, questioner. He was more exhausting than exhausted but listening to him was a rewarding, stimulating experience, even if one did not always get a chance of being listened to. He never lost his trace of an American accent, but that is where the resemblance ended. His only relaxation used to be a weekly Chinese lunch with his friends in Bombay, including visiting

friends, which he used to enjoy immensely and look forward to with youthful enthusiasm. He spoke fast and swallowed his words, because his mind moved faster and it was not easy to keep up with him. He did not suffer fools and humbugs gladly, but had a devastating sense of humour which spared nobody, not even himself. Once, at the Tata Institute of Fundamental Research, he introduced an eminent but portly visitor with the words—"Meet the expanding universe in person". A friend could take liberties with him, but if anyone else did, there was immediate trouble. He was no respecter of persons, but his own respect could be won and held. He tended to bully, but could also be bullied by affection and trust. He made enemies faster than friends, but he was loveable to his friends and a real friend in need who put himself out no end.

As an individual, he had the courage of his convictions and a high standard of integrity, was intensely human, with natural compassion for the fellow human being, especially for the underdog, but with no patience for the callous, the insensitive, the selfish and the unscrupulous. From the way he used to talk of his two daughters and they talked of him, he must have been a loving father, and I know what a good son and brother he was, never sparing himself. He was a strong individualist and much better working on his own than with other people. In his character and intellectual power, in his child-like quality and absence of childishness, he was outstanding. He was not known for his tact nor for his manners, yet he could be more concerned and considerate than most people. He made it easy to believe in him when it was so much easier to be let down, and was meticulous in meeting his obligations.

There was nothing in the world that did not interest Baba, yet perhaps a greater feeling for the creative arts could have softened some of the sharper angularities of his dominant, vibrant, human personality. He was friendly with everyone on the Deccan Queen, on which he travelled daily between Poona and Bombay and sometimes did his work. He suffered for his political convictions because he did not take the trouble to hide them, and it pained him to find scholarship being judged by political instead of academic standards. Baba was incorruptible and put principles above personalities, may be that is why the personalities were not too kind to him. It is left to posterity to do justice to his memory in a worthy manner.

One's life pattern can often be foretold from early days and so some idea of Professor Kosambi's college years may be of interest to those who had the pleasure of knowing him in India. The writer has never been able to visit India, though it was for a long time his dream to work there. When Professor Kosambi visited the United States in 1948 it was a pleasure to find him the same "Baba" that was known to us in Cambridge twenty years earlier.

Baba's father (also a Professor Kosambi) was on the Harvard faculty for several years and during that time the son attended the Cambridge public schools and became a well-rooted member of the "town." Although of course not a Christian he was very fond of the people around the Central Square Young Men's Christian Association, many of them his schoolmates, and regularly used its gymnasium, cafeteria, and movie house in preference to Harvard Square institutions. There is always a certain tension between the allegedly wealthy students of the "gown" community and the children of factory and office workers, the "town." Baba belonged to both camps but was perhaps most at home in the "town."

Years later when Baba visited Cambridge he looked up his old friends at the "Y" and he was deeply touched when a group of them formed an evening party for him and took him to see the "Icecapades." This was I suspect a greater honor and pleasure to him than almost anything else he received. It was a recognition that he was one of the Cambridge people.

From 1928-1930 Baba was one of four of us living in unheated rooms in the top floor garret of a Cambridge rooming house, 10 Trowbridge Street. Baba's room was at the top of the stairway with a sloping ceiling and single window, overlooking the

backyards of apartment houses. The only decoration I remember was a photograph of Gandhi whom he deeply revered. The room was lined with book-shelves filled with the widest imaginable variety of things. I recall *Allgemeine Sprachenkunde* (a book on linguistics), copies of the Bible in Latin, Greek, German, and other languages (which he liked to compare as language practice), a large number of paperbacks of French, Italian, and German literature, as well as books in Indic languages, and of course scientific books, mostly in German.

A little story is worth telling about his interest in languages. One spring he received a letter from his father (now back in India) complaining that Baba had only received 3 A's and a B. He suggested that if he didn't do better he was wasting his time and perhaps should return to India. Now for any ordinary person 3 A's and a B was an enviable record but not for the elder Kosambi. Baba was terribly upset and decided to remedy things. He had never studied Italian and decided to take the elementary course in summer school. He was required to read selections from a choice of two of four student editions of Italian literature. Instead he acquired all four full-length versions and studied them thoroughly. At the end of the course he received a note from the instructor saying that this was the first time in his career as a professor that he'd had to give the grade of "A+." The note was duly sent back to India without comment. One evening that fall I noticed Baba in animated conversation with a student in his room and later asked him about it. "Oh, he was working on his doctorate thesis on Dante and I was advising him about it."

On the other hand, I was taking a graduate course in atomic physics and in connection with it commented to Baba on a relatively obscure article by Einstein on the Bohr atom that I'd read in a German periodical. Baba was a math-student and had not taken even the sophomore course in physics. Much to my surprise he was not only thoroughly familiar with the Einstein paper but referred me to other Einstein work on related topics.

As an undergraduate Baba took a so-called "20" course of personalized student research from the late Professor George Birkhoff and worked on the multi-body problem. Kosambi held Birkhoff most highly among his teachers and was bothered that Birkhoff urged him to spend a larger proportion of his time on mathematics. When asked for advice his father backed Baba up saying he was pleased to see him develop the widest possible interests.

On the personal side, Baba was a fine companion going on

long walks along the Charles River bank in a region that was then in a wild state or eating in the cheap little restaurants in the "town" regions of Cambridge. After the stress of an exam period we liked to go to the YMCA movie house and see a Hoot Gibson western as a piece of comic relief, or the four of us would play a raucous and jollying style of bridge, more banter than game. Perhaps the most innocuous, insipid reading of the time was in the mass-circulation *Saturday Evening Post*, and at times Baba would like to relax with it at his stall in the Widener Library, of all places. To be sure, Hoot Gibson was diluted with, for instance, Fritz Leiber's Shakespeare, Alexander Moisei's version of "Das Lebende Leichnam," "The End of St. Petersburg," the Harvard-Radcliffe Christmas carols. When the Boston Symphony was in Cambridge, Baba could be found waiting on line for the 25-cent seats in a little balcony high over the stage.

From the time Baba left Cambridge we were out of touch for about ten years, when I happened to notice an American magazine article by him giving his address and we opened a long and frequent correspondence until a short time before his death. It was also a pleasure to establish friendship with two of his students, one of them his nephew, so I felt a greater sense of nearness to him than would otherwise have been the case at such a distance.

In 1948 I received word from him that he was coming on a visit to the United States on behalf of the Indian government. It was with a slight misgiving that I went to meet him at South Station. By then we were middle-aged. Would he after all prove somewhat pompous and on his dignity dressed in finery and staying at fashionable hotels? It was with intense pleasure that I saw the old Baba with superb physique striding up the platform in a simple business suit and carrying an enormous canvas knapsack strapped to his back! We spent long hours discussing the past and the ills of the world. On Christmas Eve he helped my children decorate the Christmas tree—his first experience with that particular job.

During his student days one of his close associates was "young Wiener," son of his father's colleague, Leo Wiener. By the time Kosambi returned, young Wiener had become the international celebrity, Professor Norbert Wiener of M.I.T., who in those days spent many hours in my Tech office flopped in an easy chair talking about Cybernetics, radio engineering, Norbert's own science-fiction attempts, world politics, the BOMB, or perhaps the prices of motels or the dialects of my family's native island of

Menorca. When they met again Professor Wiener greeted him with "Welcome, wise man from the East"—Professor Kosambi replied, "No, a wise-guy from Cambridge." I suppose I may be one of the few people who was close to both of these men. Except for physique they were strikingly similar. Both had interests as wide as the world. Both were professional mathematicians. Although I am not at all competent to judge their professional achievements, as people they impressed me as being quite similar in intellect and ability. Both had been friendly with fellow students from China and maintained life-long interests in that country. Both were authorities on scientific and cultural affairs entirely outside of their mathematical specialities. Both were outspoken critics of war and social injustice, attitudes that were not always appreciated. Amusingly enough, both were astonishing linguists. They had a fine sense of humor and of the ridiculous, and for all their complex natures both had kept simple homely touches and love of people, Norbert of the newsboys of Mexico City and Baba of his Cambridge "town" friends. The world is the poorer for the death of these two men. Let's hope the students they have left behind will carry on their work and ideals.

Reminiscences about Prof. D. D. Kosambi

My first meeting with Prof. Damodar D. Kosambi was during October 1919 at Cambridge, Mass., USA, where he was a young student of the local Grammar School. He was staying with his father, Prof. Dharmanand Kosambi who was carrying on some special work on the *Visuddhimagga* of Buddha-ghosa, the ancient Buddhist scholar, under the auspices of the Department of Oriental Studies at the Harvard University. D. D. Kosambi was about twelve years of age at that time and showed signs of a bright and keen intellect. I had gone to the Massachusetts Institute of Technology for post-graduate studies in Electro-technology and the application of electric power for Electro-Chemical and Electrometallurgical industries. I was introduced to Prof. Dharmanand Kosambi through Prof. Comfort A. Adams, the well-known Professor of Electrical Engineering at the Harvard University.

Young D. D. Kosambi used to ask me questions on various topics of scientific interest and also on sports and athletics whenever he happened to meet me. As he was a "Boy-Scout" in the Cambridge branch of "Boy-Scouts of America" and as I was also taking part in their Scout activities as a Scout-Master from Bangalore (India), I used to meet D. D. Kosambi in Scout meetings and in Scout camps on the country side. Swimming, hiking and exercises in the YMCA gymnasium as well as skating in winter time used to interest him to a great extent. In general he used to like outdoor life and developed a very good physique. He mixed with his fellow students and due to his very good record in studies and sports and athletics he became very popular with them. After a brilliant record in the Grammar-School he joined the Latin High School at Cambridge for his secondary education, and kept up his keen interest in mathematics and science. After completing his secondary school

education he entered the Harvard University for college studies, with a view to qualifying for the engineering profession.

After 1922 his father returned to India and made suitable arrangements for his son to complete his college education at Harvard University. Young Kosambi seems to have preferred to study mathematics instead of engineering and pursued his studies accordingly under Prof. Birkhoff of the Faculty of Mathematics. During the latter part of 1924 he came back to India to see his mother whom he had not seen for about six years. Incidentally he visited his uncle and other close relatives in Goa. He took a keen interest in the development of the ancestral farm lands of his father and also in the future possibilities of exploiting the mineral resources of Goa and harnessing the water power at Dudhsagar Falls in Goa near Castle-rock. He got acquainted with the work that his father was carrying out at the "Purātatva-Mandir" of Gujarat Vidyapeeth which was being organised under the guidance of Mahatma Gandhi on the outskirts of Ahmedabad near the then famous Sabarmati Ashram. He got acquainted with Acharya J. B. Kripalani who was the Principal of Gujarat Vidyapeeth, and with Muni Jinavijayaji, a Jain Guru who was also associated with Purātatva Mandir and was a close friend of Dharmanand Kosambi. Besides these cultural contacts, D. D. Kosambi spent some time hunting in the jungles of Goa and the Deccan plateaus.

As he was in India for a few months his father wanted to ascertain the possibilities of his completing his under-graduate studies in the University of Mysore or Bombay, and then go back to Harvard for post-graduate work. But due to the rigid regulations of the Indian Universities at that time which did not provide for the transfer of undergraduate students from USA to the corresponding courses of study in India, young Kosambi had to return to Harvard to resume his studies. However, the short stay in India at this juncture was very useful to him to get acquainted with the state of agricultural and industrial developments in India and to re-orient his mind and temperament and to develop an outlook that put him in a better position to serve the people of India.

After returning to Harvard Kosambi completed his studies with great distinction and graduated with high distinction—"Summa Cum Laude" and was elected to the fraternity of "Phi-Beta-Kappa" at Harvard University. Besides his professor Dr. Birkhoff he was in contact with other distinguished mathematicians like Prof. Dr. Norbert Wiener of M.I.T. of Cybernetics fame, and his other colleagues at M.I.T. and Harvard. During

the latter part of his stay at Harvard his father was again called by Dr. Woods of the Oriental section of Harvard in order to complete the special work of editing the *Visuddhimagga* of Buddha-ghosa. This was a very welcome reunion for both father and son and they made the best use of it for each other's professional studies. Young Kosambi kept up his interest in physical culture including swimming, rowing and exercises in the gymnasium and also scouting as well as long-distance hiking. He returned to India in 1929-30 after the return of his father in the previous year. Before looking out for a suitable teaching position he stayed with me for a short while in Bangalore. On my suggestion he explored the possibilities of securing a position in the University of Calcutta and Benaras Hindu University where he could meet several friends of his father. In the meantime I learnt about a position advertised for the faculty of Mathematics at the Benaras Hindu University and advised Kosambi to contact them. He was offered the position immediately which was suitable for his qualifications. Thus began his brilliant career as an able professor of Mathematics. He made his mark there and built up a school of advanced studies in Mathematics. A group of brilliant students took up research under his guidance and contributed much to the developments in mathematics in India. Later on Prof. D. D. Kosambi was invited by the Aligarh University to their Faculty of Mathematics as the Head of their Mathematics Department. Here also he applied himself with the same keen and active spirit and made very valuable contributions in higher mathematics. Due to his keenness for scientific work and a cosmopolitan outlook on University education and Campus life, Prof. Kosambi became very popular among his colleagues and his students. The Vice-Chancellors of both the Universities highly appreciated his work and were very reluctant to let him leave them.

There was a call for Prof. Kosambi from the Fergusson College at Poona where his father was a Professor of Pali several years ago before he was called to the Harvard University in the USA. Here again he was very successful in raising the level of teaching mathematics to the highest standards. While here, he came into contact with a wider sphere of Mathematics as he got into close touch with the Indian Mathematical Society which included very eminent mathematicians from the Universities of Bombay, Mysore, Madras and Calcutta. He was called to serve on the Board of Studies in Mathematics of the different Universities of India. He also took part in Extra-Curricular activities in Poona by way of welfare works among the rural populations

near Poona and outskirts. He developed interest in the study of Indian History as ascertained from archaeological discoveries and ancient coins.

About the middle of 1943-44 Prof. Kosambi was invited by Prof. H. J. Bhabha to take up the Chair of Mathematics at the newly established "Tata Institute of Fundamental Research" at Bombay. Here he found a much wider field for mathematics as it had a very important contribution to make in the researches in Atomic energy in India. He had a number of workers keenly interested in the mathematical developments which concerned the latest methods of solving intricate problems in nuclear physics and atomic energy. During his association with the Tata Institute of Fundamental Research Prof. Kosambi stayed with me as I happened to be associated with the Hydro-electric developments in Bombay state. For some time in the earlier days he used to commute daily from Poona to Bombay. But as this proved to be very tiresome he stayed with us for five years during five days in the week and went to Poona over week-ends, as Mrs. Kosambi and their children were staying at Poona. This system was rather strenuous for him and it must have adversely affected his health to some extent.

During these years Prof. Kosambi took a keen interest in the activities of the Council for Peace of the World. On their behalf he undertook several visits to Europe (Western and Eastern) as well as to USSR and China. In the Mathematical field many of his papers were published in reputed journals abroad. In 1948-49 he was invited as an Exchange-Professor by the University of Illinois, USA at Chicago for an academic year and his work there was well appreciated. He was also invited by the Institute for Advanced Studies at the Princeton University for about two months. Here he had a few important conferences with Prof. Albert Einstein regarding his latest work on "Relativity." He renewed his contacts with his former colleagues and friends at the Harvard University. Although he enjoyed his academical work at these seats of learning, he was somewhat disappointed with the steady deterioration of the cultural life in USA caused by the Second World War and the lack of appreciation for real values of life in general. He observed the conflict between liberal ideas of socialism and liberalism on the one hand with the conservatism of capitalists or diehards on the other hand. His work at the University of Illinois was so well appreciated that he was invited by the Harvard University to take up an important teaching and research assignment at their faculty of mathematics. But as he had to resume his work at the Tata

Institute of Fundamental Research, Bombay, he politely declined the offer with regrets.

Another venue of his activities was at the Bhandarkar Oriental Research Institute in Poona, where he associated with some well-known Sanskrit scholars and Vidwans. Here he edited the works of Bhartrhari and later published Vidyākara's *Subhāṣitaratnakośa* in the Harvard Oriental Series. The authorities of the British Council who had opened a chain of modern libraries in India arranged for a series of lectures by him on Indian History and Culture at some educational centres in England, which were very much appreciated. While in London he renewed his contacts with his cultural friends there among whom may be mentioned Prof. Bernal of the Physics faculty of Birkbeck College. During recent years he had planned another visit to Europe in connection with his researches in mathematics. But as ill-luck would have it, he could not carry out this plan of his. His former colleagues and students have highly appreciated his works as a brilliant mathematician and a research worker of high calibre.

Tramping with Kosambi through History

Maj. Gen. Habibullah

There are some persons who when they walk across the stage of life leave something of an aura, a presence, for which those who have the good fortune of being in their proximity are the richer for it. D. D. Kosambi was one such rare individual who strode across the great screen of human wisdom in all too rapid strides. Being an amateur archaeologist myself, I had been looking for some wise man in Poona, which is full of wise and simple men by long tradition. I was given several names but most people spoke specially of Kosambi and Sankalia. It was, therefore, by the rarest good fortune that a very good friend in Bombay turned out to be so good a friend of the Professor that he offered to bring us together. I like to think that Kosambi was also aware of my existence before that date, for, from the first moment of our meeting we became the best of friends and our friendship grew. He was said not to be an easy person to get on with; but that was, probably because, though he could suffer fools to some extent, the humbugs he could not for a single moment. He had a rich vocabulary which he could make use of with his Harvard American twang!

I did not waste time in seeking his help to found an archaeological Society in the 'hobbies' section of the National Defence Academy. Nor did Kosambi hesitate in taking on the job. I had been told he might hum and haw; to my joy he did not. From then on I cannot say whether the Chief Instructor (Army) or I was his more ardent student. Being the more senior, I left a good deal of the detailed follow up to Colonel 'Monty' Kee, as Irish as an Irishman could be, for whom Kosambi developed a great liking. Between us and under his guidance we soon had a thriving society with a band of real young enthusiasts. The first thing we did was to establish an archaeological museum to

which he gave some very rare microliths. So magnetic was Kosambi's personality that we had to limit the number of volunteers who flocked to him. It was a pleasure to watch the flame of knowledge kindle and grow in these young minds; hypnotised by the sincerity, the wit and the sharpness of the Professor's genius. "See that step-like effect there. That is a sign of early cultivation before ploughs were used" he would say as though everything was obvious. "Look at that hill with a lone tree on it. I am sure you will find pre-historic remains of worship there" or "Do you know Junāgad means old, i.e. 'Jirṇa' Nagar?" or "Oh yes, that inscription is in 'Brāhmi' script, it must be such and such period which is confirmed by the use of this letter. This sort of letter is not found after such and such date."

When he was in the field his eyes worked like those of a hawk. The most ordinary chips, rocks, ruins or carvings would have a meaning. He could as easily and quickly reject too the bogus or imitation. An ordinary annual festival at the temple near the Karla caves led to his discovery of a very ancient rite performed, before the Kolis took to fishing. He followed it up by showing how a goddess there being married to a god in the interior, had an old trade route significance. "Therefore," he said, "this is such and such place, mentioned in such and such writing in such and such century." There was never a doubt, for he would sum up facts and use them so very clearly and conclusively that there was never room for doubt.

Kosambi's father was a great student of Buddhist life and culture. This study the son had developed in great measure, and his economic theory on the situation of cave colonies proved to be fantastically accurate. He discounted the theory that caves were situated "away from the madding crowd". In fact he said, their location depended on (a) proximity to trade routes, (b) halting places of caravans or pack trains. "Therefore" he said "they should be a day's march (or measurable by days marches) apart, which should be between fifteen or twenty miles." Projecting his theory we marched towards a group of caves near the sea at Kuda. To our amazement, we came upon a huge group at Karsambla lost in a forest at the foot of the Western Ghats below Bhaja. These had once been recorded in the 1880s in some official files as "probable"; but no one knew of their context or extent. In rummaging, through the ruins we found evidence of frescos and decorations that must have made Ajanta look provincial. We found Brahmi inscriptions of which he made us take plaster casts. As we proceeded he explained

that being exposed to weather they had deteriorated all the more rapidly. Fifteen miles into the plain, there was a hamlet with roads leading to four important ancient areas including two important passes up the Ghat. Two marches away was Kuda itself!

His mind was always active, always probing and almost always original. His independence in thinking brought him face to face with many an intellectual giant; but nothing daunted him; for his intellect too was gigantic, unique. He had the most amazing tenacity and, so single minded a sense of dedication, that his own physical wants rarely stood in the way of his true and scientific approach. Yet his family life was traditional, warm and close. His house is a typical Maharashtrian middle class dwelling, filled with rare books. A glance at his well stocked shelves shows the versatility of the mind that dwelt in the Professor's physical frame. I was taken aback to see in a foot note, that he had provided the most vital missing link in the historian Robert Graves' researches on the life of Christ: Kosambi had translated some rare Sanskrit documents which had been deposited in the Srinagar Fort since their removal from Tibet by Zorawar Singh. Robert Graves quotes with respect and without hesitation the interpretation of these documents which prove the presence of Christ in Kashmir.

Though he loved Sanskrit and quoted it fluently, mouthing verse after verse with obvious relish, he could translate from Latin, Greek, Pali and Arabic well enough to be able to decipher and extract meanings on the spot. He was in search of megaliths in the Poona area at the time of his demise. He had already drawn many conclusions, relating the Deccan to Central Asia in pre-history. His mind was amazing at grasping details. I often wondered what a marvelous General this stout-hearted, rugged devotee of science and progress would have made, had he so chosen.

Internationally, he was exceptionally well known and much sought after; but he was shy and never went out of his way to seek publicity or fame. This may be why so few knew him and very few knew him well, but so many admired him once they had made his acquaintance. I remember a very intelligent General reading his smaller history book and saying "I wonder who this man is. What a fund of knowledge and what masterly writing!". Yet Kosambi could sum a man up in one meeting; and he put people in 'White' and 'Black' categories at once. There were few grays for him.

Kosambi's impact on others, I am sure, tended to impress itself

on those with whom he came in contact. Speaking for myself, it had a tonic effect. India, the Deccan, the human race seemed to take on a new meaning. Stones could be made to yield secrets of history, time could be filtered down to give interpretations to ancient texts; hope and insight seemed all-pervasive. What a varied and wonderful thing was society. What changes and turns had the histories of men and groups suffered, and how had the main stream of generations resisted the storms of changing fortune in history! All this, one could perceptibly feel when in proximity to him. Yet he was a recognized mathematician among the highest ranking mathematicians in the world and he could take even laymen into the world of numbers and make them seem to be thrilling and alive. He was a statistician of international repute.

Yes, Kosambi was a rare human; humanistic in the extreme, compassionate, humble with the humblest and a giant among the proudest giants. That was the man I, and many of his friends, had the good fortune to know during an all too short life. His loss to us is great; how great has been his contribution, only future generations will tell. He was a rare aroma in the garden of man's achievements. He was not "the stuff that dreams are made of" but the solid earthy stuff on which the future of man is founded.

The death of Professor D. D. Kosambi on June 29, 1966, at the age of fifty-nine removed a unique figure, not only from India but from all society.

Kosambi had a most unusual and comprehensive education, partly in the United States, at Harvard, where his father taught Indic studies. He acquired early an interest in mathematics, which was his main contribution to science, particularly in the field of statistics and Stochastic Theory. This put him in the front rank of practical mathematicians and his interest was then transferred to theoretical and nuclear physics and he worked on fundamental research at the Tata Institute in Bombay under the general direction of the late Homi Bhabha.

I am not qualified to comment on his mathematical work, especially as much of it is concerned with number theory and calculus of variation; but I had a great deal to do with him as a man of quite exceptional intelligence and charm, particularly in the work concerned with the Indian peace movement, and I learned something of his wide scope of interest. Although trained in the United States, he remained from the very beginning mainly concerned with Indian problems, including Indian economics, history and archaeology. It was a pleasure to travel with him in his own country because, for Kosambi, history was not only in the past but also in the present.

In the extremely unsatisfactory records of Indian history which he has denounced in his books, he finds the preservations, of beliefs and customs in many tribes and castes. He finds, for example, not only the places of worship but also actual names, such as that of the goddess Lumbini presiding over the birth of the Buddha, which has been preserved locally practically unchanged for 2,500 years. I witnessed one of these survivals

myself outside the National Chemical Laboratory near Poona. It was a newly established shrine with a crude figure smeared with red paint and an attendant ascetic who, for a consideration, would offer up a prayer so that the new arrival into the laboratory could be assured of a good post.

Kosambi's interest stretched further than the geography of India. I accompanied him to the National Museum of Denmark in Copenhagen and he was able to tell the curator precisely what bones he would find at the bottom of a well because the Bronze Age Danes had the same horse sacrifice as the ancient Aryans of India.

Wherever he went he was able to trace out the early trade routes still in use in the age of steam and motor cars, and often transporting the same goods including pots made with the slow and fast wheel, that had already been made in the Indus civilization in the second millennium B.C. For this he had also to perfect his knowledge of Indian languages and poetry. His father knew the whole of the *Pali Tripitaka* by heart, and I remember Kosambi taking me to the Institute in Poona where a number of aged Indian scholars and their younger disciples were occupied in providing a comparative edition of the *Mahābhārata* of 100,000 lines from numerous manuscripts on palm leaves and other fragile bases, reckoning that they had done a good day's work when they had completed one line!

Kosambi introduced a new method into historical scholarship, essentially by application of modern mathematics. Indians were not themselves historians: they left few documents and never gave dates. One thing the ancient Indians did leave behind, however, were hoards of coins. These carry no inscriptions which list kings or date markings, but they had been in circulation before the hoard was buried and had suffered varying degrees of wear before burying. By statistical study of the weights of the coins, Kosambi was able to establish the amount of time that had elapsed while they were in circulation, and so set them in order and to give some idea of their respective ages. In this way he was able to date these coins known as punch-marked coins, weighed pieces of silver of carefully standardized weight marked with various devices which connected them with a definite king, sometimes many with a single king such as the great Asoka of the Maurya dynasty. The persistence of a coin is one of the most remarkable of human characteristics. In his book, *The Culture and Civilisation of Ancient India in Historical Outline*, Kosambi shows a picture (No. 62) of a coin of a Greek king, Menander, in North India, 180-160 B.C. which he found in

1940 circulating in an open air market in Poona as an equivalent of half a rupee.

His great contributions to historical science have been his two books *Introduction to the Study of Indian History* (Popular Book Depot, Bombay, 1956) and *The Culture and Civilisation of Ancient India in Historical Outline* (Routledge and Kegan Paul, London, 1965). These provide a history of an entirely different character to anything seen before. As he himself says in his latter book:

"But what is history? If history means only the succession of outstanding megalomaniac names and imposing battles, Indian history would be difficult to write. If, however, it is more important to know whether a given people had the plough or not than to know the name of their king, then India has a history. For this work I shall adopt the following definition: *History is the presentation in chronological order of successive changes in the means and relations of production.* This definition has the advantage that history can be written as distinct from a series of historical episodes."

In his second book, Kosambi certainly bears out his definition. He shows a picture of a two-bullock plough of the same characteristic type with vertical handle and curved yoke-pole, taken from a relief of the Bodhisattva's First Meditation in the Buddhist caves at Junnar, as in use in A.D. 200 and still in use there at the present day. They are, for all practical purposes, identical.

A great deal of Kosambi's book is taken up with the description of classical Indian political science. The *Arthaśāstra* is a complete and almost Machiavellian description of how the great Indian state of Magadha (300-184 B.C.) was ruled and how the institutions of the complete police state could be adapted to the tenets of the purest Buddhism. He shows that the positive task of the Mauryan State consisted of opening up the territory of the Ganges Valley, including Bengal and even Assam, by clearing the tropical forests and assimilating, through institutions of Hindic religion, the local populations.

All this may seem very far away and long ago, but to Kosambi it was all in the present as well, illuminating the current difficulties of Indian agriculture and industry.

"When gunpowder had blown Arjuna's bow and later feudalism off the map the Indian intellectual still turned instinc-

tively to the (Bhagavad-) Gitā to find some way of coping with patriotic needs in the new world of banks and shares, railroads, steamships, electricity, factories, and mills. . . . The Gita is honoured oftener than read, and understood far less than it is recited. After such mixed ideas are displaced by clear-cut thinking based on a firm grasp of material reality, the work may still furnish some aesthetic pleasure for its power of expression and peculiar beauty."

This article is in the form of reminiscences of my contacts with the late Prof. D. D. Kosambi. I came to know him first in 1941 when I shifted from the Deccan College Campus to the Janglimaharaj Road. At this time *viz.* in 1942 I had just returned from the First Gujarat Expedition and I was invited to give a lecture on the Foundation Day of the Bhandarkar Oriental Research Institute. For some reasons, Prof. Kosambi could not attend this lecture. And when he met me sometime later, he told me how sorry he was for his inability to attend my lecture. Later he came to my house with some reprints of his articles and before taking leave of me, he invited me to go to his place, and when I went on the following day, he was very kind and hospitable and he almost forced me to have some refreshments which I was not used to. And from then on for a number of years we used to exchange our reprints, the most common subject being coins on which he had prepared a very interesting and original article by weighing the coins. By a careful examination of the coins, he found out how the statistical approach could be made use of to find out their age. So when I happened to acquire a similar hoard of punch-marked coins from Nagari in Rajasthan in 1955 and published the results in 1956, I sent him a copy of the article. He said that the hoard was welcome because it gave us a large number of punch-marked coins in the graded series, though they were not useful from the statistical point of view. And then I realized how very ignorant I was of the statistical method, because I thought that this hoard would be as precious as the one studied by Prof. Kosambi, *viz.* of Gupta coins.

Then came a period of estrangement. How this estrangement took place, I do not know. Prof. Kosambi began to criticize our

excavations (without meaning me or my colleagues specifically). So when I met him in the Deccan Queen after several years I went out of my way to meet him and ask him why he had taken such an antagonistic attitude. He then said that somehow or other he could not understand our report on Maheshwar and Navdatoli nor did he agree with my interpretation of the evidence, viz. on the Chalcolithic culture at Navdatoli which I said belonged to a Puranic phase of our history. Prof. Kosambi was always a very difficult person to convince and he went on persisting in his attitude and this came out in a most violent form when he criticized my book *Prehistory and Protohistory in India and Pakistan* in a severe way in the *Times of India* (1964). Immediately I wrote to him that the review was quite unfair because the book was an exhaustive survey of all that was known and it was—more than 60 to 70 per cent based on the original work done at the Deccan College and also other unpublished works. To this he did not reply. Then I also invited him to pay a visit to our Institute and see our museum and the work done by us in the Institute. To this also he did not send me a reply. After a couple of months or so, he wrote to me saying that in the heat of the argument, he forgot to write about the work he was doing on some problem and wanted to know whether he could visit our museum and take some photographs. He particularly mentioned that he must have full liberty to handle things and take out objects as he pleased. I said that the entire museum was at the disposal of scholars like him and that there would be no restriction on his handling or photographing any material. When he came to the Department, I showed him all our pottery, stone tools, particularly the section on Nevasa. When he saw all our collections, he was indeed surprised at the way things were exhibited and the work done by the Institute and immediately asked me to allow him to photograph the Nevasa section. He also took photographs of the mother-goddess from Nevasa and elsewhere. Before he took leave of me, he took a colour photograph of mine saying 'Please tell your colleagues and friends that this photograph has been taken by one of my most severe critics.' Thus the visit of Prof. Kosambi ended on a happier note. But a still more happy moment was to come when we spent several hours together, almost the whole afternoon, in surveying all the megalithic monuments that he had discovered in the Poona District. He took us from one monument to another and went on explaining how he thought that these were prehistoric monuments, exactly like the megaliths of Mysore, Andhra and South India. He also

thought that these in some way or other continued the tradition of the prehistoric or protohistoric cultures, etc. Here I must say that I had myself decided not to contradict him and also advised all my colleagues not to contradict him on the spot because this would have led to a very furious argument. In the first place we were seeing one of his most important life-works and therefore before any comments could be offered we had to understand his viewpoint and only then offer criticism.

Immediately afterwards he invited us to see the specimens of prehistoric carvings which he had collected and kept in his house and those which he had seen on the Vetar Hill. The latter could not be taken out, as they were in danger of being dynamited and he thought that I should use my influence and protect them from further damage. So my colleague Prof. S. N. Rajguru and I with one or two other colleagues went to him one day in the early morning at about 5.30 a.m. Unfortunately, it was on that very day we heard the shocking news of the death of Sri Lal Bahadur Shastri at Tashkent. Still both Prof. Kosambi and myself were made of such stuff, that this news did not deter us from doing our job, and we spent 5 useful hours surveying in detail all the things that he had observed on the Vetar hill. And alas! this was our last meeting.

Whether one agrees with his conclusions or not, one must admire the great tenacity of purpose and interest with which Prof. Kosambi had moved about in these parts of the Deccan and observed things for himself.

It is needless to say, that Kosambi is to be rated as one of the foremost among the patriotic intellectuals of India. The contributions to this volume by learned scholars will offer enough evidence of this. The present note seeks to show, how Kosambi was free from all inhibitions in his intellectual pursuits. He would freely mix with all the cross-sections of the community to understand the human problems, as he was convinced that this was the first step to seek solutions for them. He became one with them while he was with them and made the people feel that there was no barrier of any kind between him and his fellow beings. A few incidents will illustrate this aspect.

He often visited his friends in the medical profession. If he had to wait for his friend and if there was a large gathering of patients who wanted minor treatments for their wounds and injuries, Kosambi would not hesitate to wash and dress the wounds even if they were found on the legs or head. He was fully equipped for this. He had taken good lessons in first aid and nursing. He fully made use of this knowledge to offer his services and made them feel one with him. He would often go to the villages regularly and run such "Medical Camps" not only to relieve the pains and sufferings of the people but also to learn more about them and their problems. He would not hesitate to "inflict" such treatments even on his own aged mother if he found it necessary, in spite of her protests, until the venerable lady would yield and say, "It is not worthwhile to resist Baba's bullying!". Kosambi did not sniff at the indigenous drugs or their treatment. Once he came to know, that a local massagist was preparing a kind of medicated oil which would give some relief to pain in the joints. He visited the "Institute", of the healer and bought a bottle of oil and tried it on himself first.

When he found relief, he began to extend this treatment to hundreds of friends not only in India but also in Europe and America and other countries.

Kosambi was a frequent visitor to Bangalore and he was curious to know about many interesting features of Bangalore. One of the most popular festivals in Bangalore is "Karaga" which comes off on the fullmoon night during spring months of March-April. The main ceremony consists of a procession of 'Karaga' (decorated triple pot) carried by a male priest dressed as a woman. By careful examination of all the details of the rituals, he was able to show that this symbolises the transition from matriarchy to patriarchy. It took a number of years of patient observation and meeting priests of all communities connected with this ritual. He would approach the most orthodox Brahmin priest as politely as he would the priests of the so called 'low castes' and 'untouchables'. By such intimate and friendly contacts, he gathered the required information for his work from the existing society; he was as much at home with shepherds as with scholars.

While he was running the campaign: "Peace by peaceful means", he addressed hundreds of workers, students and scholars with equal enthusiasm and fervour. One of the elderly statesman and an important, respectable scholar in Bangalore expressed his desire to meet this "Revolutionary", although he did not approve of his philosophy. Kosambi heard about this and learnt that this elderly person was bed-ridden. Immediately he took a transport and went to see this invalid person. He sat beside his bed and first made kind enquiries about his health. The old gentleman burst into tears with joy when he learnt that the enquirer was no other than Kosambi whom he was longing to see for nearly 2 decades. The sick man forgot his illness and carried on conversation with him for nearly 3 hours and it was Kosambi's consideration for the former's health that brought it to a close.

Reminiscences of Prof. Kosambi

The news of Professor Kosambi's death came as a great shock to me. I had not heard about his illness, and, therefore, did not know that he was so critically ill. It is an irreparable loss not only to the world of Learning and Scholarship but also to those who had the privilege of enjoying his warm and inspiring friendship.

I had known him closely since the early 1930s, and used to meet him quite often for a number of years. The Library of the Indian Mathematical Society was located in the Fergusson College, Poona, and as Secretary, and later President, of the Society, I had to go to that city very frequently. He insisted on my staying with him and was a most charming and thoughtful host. The late Vijayaraghavan also joined us there some time, and our discussions on these occasions were most stimulating and of absorbing interest to me.

When I first met him at a meeting of the Indian Mathematical Society in 1932, he had just launched on his researches in "Path Spaces", and had a close contact with some of the internationally well-known mathematicians, especially of the School of E. Cartan, who were working on the same lines. His reputation as a vigorous and outstanding mathematician was spreading far and wide. Other universities used to send their research scholars to work with him for their doctorate degrees. He was a most exacting teacher, and demanded the highest standard and consistent hard work from his pupils. I had to act as an examiner with him sometimes, and I could see how he pursued a candidate until he had extracted the last bit of information out of him.

He had no worldly ambitions, and preferred to work in the Fergusson College of the Deccan Education Society in Poona on

a nominal salary rather than take up a lucrative job elsewhere. I had wanted him to come as a Research Professor at the Osmania University on quite a high salary, but he was content with his life at Poona. When the late Dr. Bhabha invited him to join the Tata Institute of Fundamental Research, he was still hesitating and asked my advice. I was able to persuade him to join the Institute not because the emoluments were higher but because there was a better chance for him to do his own work and to train younger mathematicians there. Another argument in favour of the move was that the Institute was situated in Bombay so near to Poona, and he could visit his favourite residence regularly every weekend.

He was a versatile genius and could easily switch his mind from Abstract Mathematics to problems in Numismatics and Archaeology. The proximity of his home to the famous Bhandarkar Oriental Research Institute at Poona attracted many scholars of Classics and Ancient History to him, and they came to consult him on problems connected with research on the Ancient Civilization. Some of his acquaintances thought that perhaps he was frittering away his energy on trivial problems unconnected with Mathematics. He was, however, satisfied that he was doing useful and worthwhile work, and a number of eminent scholars agreed with him.

Another trait of his character led him to wage a crusade against any injustice that he came across, and he championed the cause of the down-trodden with all his vigour and courage. He was absolutely out-spoken and was consequently not very popular with the higher-ups. He suffered for his convictions, and I had an impression from his last letters that he was not getting on very well with other people.

He was also a very keen reader of detective stories, and used to take them as a pastime for solving mysteries. His Reading Room was full of such books, and we used to compete with each other in unravelling the mysteries as quickly as possible.

One passion of his early youth which remained with him throughout the greater part of his life was the exercise in weight-lifting. He was a very strong man physically, and was in the habit of boasting to his intimate friends that he was the "strongest" mathematician of his time. This was, of course, implied in the sense of physical strength. We used to warn him not to overdo the exercise, and I have an apprehension that this habit had something to do with the damage to his heart which ultimately snatched him away from an active and vigorous life.

10 Extracts from the Tributes

W. Seidel

His place will be hard to fill, and all those who came in contact with him will feel his loss painfully. As a mathematician and as a savant, he has a secure place in history.

The late Professor D. D. Kosambi and I were classmates at Harvard University in the years 1925-1928. We frequently attended the same classes in mathematics and became good friends. Professor Kosambi, whom I called "Baba", impressed me deeply by the brilliance of his mind and the wide range of interests which he exhibited. He was a man of great personal charm and attractiveness.

I left Cambridge, Mass. after my graduation from Harvard to do graduate work in Munich, Germany, and did not see Kosambi again. However, we maintained contact through correspondence, and I was shocked to learn that he had left Harvard before obtaining his Ph.D. in mathematics there. This was the time of the market crash in the United States. As a result, academic positions became very hard to find, as I discovered on my return in 1930. The authorities at Harvard were in great difficulty to find positions for their graduates and Kosambi was discouraged from completing his studies at Harvard.

In spite of these difficulties Kosambi attained great prominence even in other fields, such as Indian archaeology.

I shall always treasure my association with this remarkable man.

As I can recall after about 25 years, it was as Governor of the Reserve Bank that I first met Prof. Kosambi. I presided at a lecture he delivered in Bombay on a horde of punch marked coins dug up at Taxila. The treatment was statistical and somewhat novel in numismatics. I was highly impressed, not only by this side light of Prof. Kosambi's mathematical talents, but also by his transparently and uncompromisingly candid personality.

In those days I used to visit Poona quite frequently to see some very dear friends there and Prof. Kosambi and I often met in the train between Bombay and Poona and our acquaintance gradually developed into a somewhat uneasy friendship. Prof. Kosambi's intellectual interests were, I soon discovered, surprisingly wide, and his observations on men and things within this ambit were refreshingly frank. He was good enough to send me from time to time copies or reprints of some of his writings, that he thought would interest me. Those included his edition of Bhartṛhari's *Satakas*, articles on rock caves in the Western Ghats region and an article on *Bhagavadgītā*. This last was critical to the point perhaps of seriously angering Hindus, challenging as it did the conventional standing of the *Gītā*, even in the eyes of Sanskrit Scholars of repute. From their point of view, it could even be discounted as Buddhist partisan sally against something regarded as very sacred by the Hindus. Of his major interest and profession, mathematics, he naturally did not say very much as I am no mathematician and could not share his professional interest.

After I left Bombay my contacts with Prof. Kosambi naturally grew much rarer, although we kept up a sort of long range friendship. His sudden demise was a great shock to me, as it must have been to his friends and admirers — I am sure a very wide category.

Professor D. D. Kosambi commanded an unusually high respect among the student community at Aligarh which liked to interpret his initials 'D D as Doctor of Divinity'. Athletic in appearance and magnetic in association, Professor Kosambi was a unique personality in the domain of Indian education.

Professor Kosambi as a Scholar

A man of versatile genius, had practically mastered a number of European languages including French, German, Italian and Russian. He could speak in any one of these languages almost as if it were his mother-tongue. He had enough knowledge of Greek and Hebrew also. I know it personally in as much as he used to quote from Greek and Hebrew in his classroom lectures.

He was a voracious reader and had a profound knowledge of European literature, history and economics. He was particularly conversant with the philosophy of dialectical materialism as propounded by Marx and Engels.

He had taken only a Bachelors' Degree in pure mathematics at the Harvard University and yet had a complete grasp over the latest developments of mathematical research in Europe. His knowledge of the subject was so sound and penetrating that it looked almost fundamentally different from what was prescribed in the curriculum for mathematics in the Indian Universities by the conservative system of education derived from the British.

His extensive reading and vast learning had made him a man of progressive views much ahead of his co-religionists. He was deeply interested in mathematical researches and the learned discourses he gave on history and economics in private conver-

sation clearly established that he well deserved the title conferred upon him by the student community.

Professor Kosambi as Individual

Professor Kosambi was very simple in his habits; his dress too was very simple. I have often seen him in shorts in the market. He was often seen in the class-room in shirt and pant, with Peshawari chappal. At home he had no drawing-room or sofa-sets, but huge almiras full of books. He had a good appetite and enjoyed good food. In spite of his being a Brahmin he never hesitated in taking meat openly and even in the presence of his co-religionists. In Delhi, he always dined in Muslim hotels and he had taken a fancy for food cooked in a small hotel known as Shahjahanpuri hotel in Chandni Chowk near Fatehpuri mosque. He had told me, that in Delhi he could get the best food only in the Shahjahanpuri hotel and advised me to taste chicken and *Qorma* of that hotel. When in Delhi I did actually search out that famous hotel liked by Professor Kosambi and found that whatever he had said was absolutely true. In private, when he was alone with me he would like to talk in his mother-tongue Marathi. I seemed to be the only student in Aligarh who could speak Marathi with him. He was very fond of Marathi literature and whenever I quoted to him some relevant passages from a famous drama known as "Ekach Pyālā" he felt exhilarated. He was a fluent conversationist and would hardly allow others to speak when he was talking. When his statement was contradicted he laughed heartily and was always ready to admit his mistake. He always asked me to recite Sanskrit poems of which I knew a lot and he would then start his philosophical discourses quoting Goethe and the German philosophers.

Professor Kosambi was nationalistic in outlook and was deeply convinced about the greatness of his own country. It was this that had brought him back to the sub-continent from America and he had joined Benaras Hindu University as a Professor of Mathematics. But as the atmosphere of orthodoxy, narrow-mindedness and complete indiscipline among the students that he found there was not palatable to his progressive views, he was thoroughly disappointed and his rebellious temperament was in search of a more free atmosphere and disciplined social environment. He was therefore planning to leave Benaras as and when opportunity permitted him.

Professor Kosambi as Teacher

During the regime of Dr. Ross Massod, as Vice Chancellor of Aligarh Muslim University, a French Jew by name Dr. Andre-ville was appointed as Chairman of the Mathematics Department. He was a very brilliant scholar of Mathematics, who had broken the record in the University of Paris at a very early age. On his arrival in Aligarh he was feeling like fish out of water. He went round India in search of men of his calibre and met Professor Kosambi and Dr. Raghavan in some conference in Calcutta. He persuaded both of them to join the teaching staff of Aligarh Muslim University and thus Prof. Kosambi came to Aligarh. Dr. Raghavan and Dr. Andreville were quiet by temperament and were always engaged in solving mathematical problems in the staff-room. There used to be a black-board in the staff-room on which the latest mathematical problems used to be written and the two professors used to sit dumb gazing at the black-board. As soon as Professor Kosambi entered the staff-room the atmosphere used to change suddenly. Looking at the black-board Professor Kosambi would start immediately in French and would rush to the Board in order to solve the problem. The two sitting professors would find themselves perplexed and would listen to the discourse of Professor Kosambi as students. He would immediately solve the problem giving references to French and German authors and the two professors used to be satisfied with the approach and solution of Professor Kosambi. Thereafter the two professors used to take out those books referred to by Professor Kosambi and start reading them.

In the class-room Professor Kosambi was very simple and would develop his topic from the very elementary principles of the subject. After explaining the preliminaries to the students he would create interest in them to understand the problem correctly. Professor Kosambi then was a gushing stream of knowledge. He was absolutely thorough and upto-date in his subject. He would illustrate the most intricate problems of mathematics in a very simple manner always giving references to French and German authors.

Professor Kosambi in his zeal to impart knowledge was making an attempt to enliven the subject and its teaching by making it more utilitarian in its application. The knowledge of the students unfortunately was grounded on outdated knowledge of the subject and they were thus feeling uneasy in following him when he developed the topic on modern lines. Aligarh in those days was behind times in so far as this subject was concerned. But in the class his teaching was superb. His explanation of the

fundamentals was illuminating; his treatment of the topic was analytical and full of references. With his nimble tongue and fluent speech the class-room used to be a highly entertaining place.

As teacher Professor Kosambi was conscientious. He was aware, that the subject he was teaching was very dry. He could sense when the students were likely to be bored, and then immediately he would introduce an entirely personal topic *e.g.* in reference to his own student days or narrate a story of some witty author that would set the class room into a roaring laughter.

In order to keep pace with the advances made in the subject elsewhere he sincerely advised the students to study German and French, and particularly he used to emphasise that it was absolutely essential to study German to complete one's study of mathematics.

Outside the class-room Professor Kosambi was an intimate friend to all students. He treated them as members of a family, posing himself as a *Pater familia*. He was a source of inspiration to students as he went on talking about social and political problems. In private he used to discuss prominent Indian personalities. I quite remember when he started discussions about Dr. Zakir Hussain, the then President of India, as an Economist. He was full of praise for him and always took the opportunity of meeting him.

He was a great mathematician of the sub-continent. He left Aligarh after Dr. Andreville and Dr. Raghavan. Later on he joined the Fergusson College, Poona and served the people of Maharashtra. His death is a great loss to the mathematical world.

My father, George David Birkhoff, took a warm personal interest in "Kosambi" (as he was known to the Harvard Mathematics Department), whose many-sided brilliance and charm stood out in classroom and living room alike. The versatility and originality of his later mathematical work which (like some of Wiener's work) showed imaginative insight even when it was not rigorous, amply justified this early promise.

Kosambi's mind was versatile. Though a scientist and mathematician by profession, he took an interest in history, and brought to its methodology an original approach. Kosambi was a Marxist by conviction, and his definition of science has Hegelian echoes—"Science is the cognition of necessity."

Science had a continuity that other subjects lacked. He often said, "I stood on other people's shoulders, still others will stand on mine." The job of science, he wrote, was to make "better and better approximations to the truth", ('Science and Freedom') but for science to make an advance, the scientist needed freedom, yet he found himself surrounded by restrictions on what to think and what to say. For instance, Galileo's astronomy was thought dangerous, because Galileo by stating factually what he saw, challenged the prevalent theory of the ruling class and its right arm, the Church, so that "... by implication the rest of the social system was also laid open to challenge, something no man is free to do without risk," (*E.E.*, p. 49) then or now. Kosambi spoke from personal experience. He knew the fetters Big Business could and did place on a scientist with an inquiring mind, questioning all matters.

Science flourished when the scientist carried on his investigations unhampered, which was the case during political upheaval, when a new class gained power. Along with the rising class came a bumper crop of scientists: Newton, for example, whose discoveries coincided with the rise of the bourgeoisie in England. Famous French scientists sprung up after the French Revolution smashed the feudal system. The bourgeoisie needed and encouraged scientific discoveries. But to Kosambi there was no justification to tie science to the apron strings of a decaying class just because that class in its prime 400 odd years ago, had

brought into existence science as we know it today. The world and the bourgeoisie have changed since then and the scientist needs to be free of that class, for, "... if he serves that class which grows food scientifically and then dumps it into the ocean, while millions starve all over the world, if he believes the world is over-populated and the atom bomb is a blessing that will perpetuate his own comfort, he is moving in a retrograde orbit on a level no beast could achieve." ('Science and Freedom')

Though not prone to imagine virtues in the bourgeoisie, Kosambi gave that class full credit for being the harbinger of modern science. But the bourgeoisie *per se* is not essential to scientific growth and the reason why the scientist in today's capitalist society feels choked is that the class he serves fears the change it sees in a different social structure which has managed to survive and to thrive without a bourgeoisie. This difference cannot be freely discussed by scientists in the 'Free World' he noticed. For if they did, they risked losing their jobs. Studying a different social structure, inquiring into and questioning the social need for the bourgeoisie, or for classes today, are topics debarred from scientific inquiry.

After World War II, scientists grew worried about their dwindling freedom, which Kosambi found out, meant pursuing their work in their chosen field, and being paid for it by Big Business, war departments, or universities whose funds depended chiefly on these two sources. So scientists were "under the necessity of producing regular output of patentable or advertising value while avoiding all dangerous philosophical or social thought." ('Science and Freedom')

Kosambi laid bare the class basis of science and called it "the theology of the bourgeoisie". In the days of handicraft production, before machines came in, technical knowledge was passed on slowly and production limited. And when the indebted craftsman mortgaged his tools, they brought no profit to the usurer though the craftsman starved. So there came into being a new class whose labour could be exploited. The usurer became the capitalist and the craftsman formed the proletariat.

This necessitated fresh thinking to fit in a managing class which doesn't handle the tools of production. Here Science came into its own, and Galileo's study of pumps, for instance, resulted both in hydrostatics and more efficient pumps, because, "Science is nothing if it does not work in practice. In Science, practice and theory cannot be divorced." (*E.E.*, p. 44) Kosambi often stressed that science was not the result of talented people thinking up scientific problems in their minds. Only when

there was the social need, did the necessary invention come up.

Dialectical materialism was the method Kosambi followed in his study of ancient Indian history in which source material is meagre and chronology, extremely difficult to fix. Kosambi's basic method of tackling chronology was by demarcating periods in history according to the means of production, not by battles or changes in dynasty. But here too, Kosambi recognized that in an undeveloped society, socio-economic forces guiding historical development, major wars, major changes in rulers, major religious upheavals, all revealed the fundamental changes in productive relations. Kosambi regarded these as basic, while they had been ignored by earlier bourgeois scholars. In addition, India had an uneven course of development, what with the size of the country, the different languages and differing natural environments, so that even if some ancient document did reveal the mode of production and so the level of development of that society, it would be a job to fix its chronology. Unlike Brahmin records, Kosambi found Jain records more dependable. The Jains had a large number of traders to whom years and dates meant something, and they had to get their records straight.

Another difficulty faced by any student of ancient Indian history, was the terms used. Terms can be, and have changed their meaning, and Kosambi noted that this was more so in India where the priestly control over Sanskrit led to secrecy, to memorising, and consequently, to ambiguity. Kosambi suggested that a scientific Indian chronology would be possible only by the method of citation. Researching into the earliest mention of customs, techniques, and foodstuffs was one of his methods. "Digging in the right places" could help evaluate written sources, such as the Mahabharata War or Rama's invasion of Lanka.

Slavery in India was another disputed issue to which Kosambi tried to find an answer by relating it to the method of production. Greeks and Romans, accustomed to slaves, couldn't recognize any class that looked like their own slaves. Besides, neither in inscriptions nor in literature is there any mention of slaves taken in battle, slave marts or caravans of slave traders. Kosambi concluded that *dāsa* or *śūdra* were alternate terms describing the same thing. The caste system according to Kosambi prevented slavery in India in the Greco-Roman sense. The Aryans destroyed the earlier Indus Valley civilization, with an urban population comparable to the early Sumerian. The urban population must have been kept going by a large, surplus-producing agrarian population, who became the *dāsas*. The

Rgveda mentions two *varnas*, as caste was then known — the *Ārya* and the *Dāsa*. Later on *Dāsa* acquired the meaning of *Śūdra* and the *Śūdra* served the three upper castes. The other ground on which Kosambi refutes the possibility of classical slavery in ancient India is that at the time of the Aryan invasion, the Aryans had no private, only tribal property, and the *Śūdras* were the slaves of the entire tribe.

In the course of his study of ancient Indian history, Kosambi found tribal people whose lives, because of the availability of food, had remained basically unchanged when too much deforestation hadn't ruined their traditional food and living habits. With plough agriculture began the mutual acculturation of food gatherers and farmers, who, in time, found their place in the caste system, and the foodgatherers contributed their two main don'ts — not accepting food from a stranger and no marriage outside the tribe — to the caste system. Kosambi also traced the tribal origins of many Hindu diets. One of the tribes he studied, was the Ras Phasé Pardhis, nomads of the Deccan.

Field work played an important part in Kosambi's study of history. He came by evidences of mutual acculturation first hand. He went over to the farmers, unmindful of heat, dust, or their unhygienic conditions. More important, he crossed the barriers formed by generations of poverty on the one hand and exploitation on the other. "Such field work," he wrote, "has to be performed with critical insight, taking nothing for granted or on faith, but without the attitude of superiority, sentimental reformism or spurious leadership." (I.S.I.H., Pref. vii)

Dialectical materialism found its way into Kosambi's views on literature. He felt that arrangement of words alone did not make an author great and that Shakespeare's greatness was due to his expressing a new class basis. In those days, the bourgeoisie was the rising class, and their interests coincided with those of the oppressed. To be great, Kosambi held, a poet had to show up some part of the social structure and the seeds of its negation, which happened during the emergent stage of a new class. With his scientific mind always on the lookout for suspicious coincidences from which to draw general truths, he felt: that was why the greatest names in literature come at the emergent and not the decadent period of a particular class, and why literature, fulfilling these requirements outlasts the society it reflected.

But after a socialist revolution, somehow, the literature in the socialist country lacks both the power and the literary forms which arose during earlier social upheavals. Kosambi, with his

critical admiration for socialist achievements explained: that was because the new class in earlier societies emerged while the old class was dominant. The new class turned to literature to express its hopes and aspirations because any political expression was denied it. But when in a socialist society, the working class gains power, it gains political expression. The struggle has always been bitter, and the new, socialist country tries to reach the advanced level of the older capitalist countries, which have probably tried to kill its socialist revolution. On the literary front, writers face another difficulty, in that they have spent their formative years in the old society. Classless society did not exist as far as one can remember; and the literary production takes on what Kosambi called the 'boy-loves-tractor' pattern. Party directives and writers' conference resolutions cannot remedy the situation. The cure, as Kosambi saw it, was to abolish illiteracy and make classical works in that language easily available. In addition, he felt that some way had to be found to link the aesthetics of the new socialist society to production, and then new art forms would develop, as music did, originally, to make the crops grow, and dance, drama, painting and sculpture originated in primitive initiation rites and sympathetic magic.

But these developments, however beneficial to mankind, need one pre-requisite, peace. The argument that war requirements allotted vast funds for research and scientific development, was, he felt, "vicious." He wrote, "Quite apart from the destructiveness of total war, the crooked logic of Big Business and war-mongers is fatal to the clear thinking needed for Science." (*E.E.*, p. 97) Kosambi felt that lasting peace had to be based on "true democracy", where all men were truly equal and no one could claim any superiority by virtue of any right whatsoever, whether divine, of birth, conquest or that of private property. Otherwise peace, as imperialists have seen it over the centuries, would have no meaning. Kosambi often quoted Tacitus on the subject, who had written, "He made a desert and called it peace," referring to a contemporary Roman Emperor. To Kosambi, it was "twisted logic" that waged war in the name of peace, and "which bombs people indiscriminately to save them from Communism." (*E.E.*, p. 96)

Being an active fighter for peace, Kosambi went into the causes that prevent peace, and saw in food a powerful weapon in the war against mankind, excepting that fraction of the people to whom food is a very minor item of expenditure. "In a word it is *class war*, and all other wars of today stem from

attempts to turn it outward. Even the Romans knew that the safest way to avoid inner conflict and to quiet the demands of their own citizens, was to attempt new conquests." (*E.E.*, p. 97) World War III, Kosambi felt, was not inevitable, and that public opinion, once aroused, could stop it; and he spared no effort in mobilising that public opinion. He also felt that colonial liberation would help the cause of world peace, being one step towards making "have-not" countries a thing of the past.

Kosambi's approach to life was based on his Marxism — but not its blind, uncritical application. "Marxism cannot be reduced to a rigid formalism like mathematics, nor can it be treated as a standard technique such as an automatic lathe." (*E.E.*, p. 4)

The way to cherish Kosambi's memory is to acquire a mastery over his methods.

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I had the honour of knowing Kosambi for many years. I first met him when he was in England as a guest of the British Council to give a series of lectures, to which he invited me. I knew him by repute as a mathematician and therefore declined to go to the lectures since they would clearly be above my head. He reacted somewhat violently to this thought of mine and told me that in fact his lectures were to be on the subject of mesolithic archaeology. It was thus for the first time that I realised how broad were his interests and how complete a polymath he was. His interests were extra-ordinarily wide-ranging. When I took him to Salisbury Plain to show him the great monument of Stonehenge, I found that he was familiar with all the background and with all the interpretations put upon the monument by English antiquarians since the seventeenth century. He was well read in medieval Latin texts, an authority on the punch-mark coins of western Asia, skilled in the science of genetics. Like a latter-day Lord Bacon, he had taken all learning to be his province. He was not only learned but a stimulator of learning in others.

In 1951 Kosambi published a paper on the R̥gveda (*JBBRAS*, 27, 1951, pp. 1-30). In this paper he transliterated the original Sanskrit text into the Roman alphabet, thus making the original language available to people like myself with no knowledge of the Sanskrit script. He published with the transliterated text a literal English prose translation.

In his paper, Kosambi proposed that the passage *RV. X. 95* was not a narrative of factual events but rather a formal dialogue from some ritual now lost. In discussing the matter with Kosambi I was impressed by the percipience of his interpretation and caught some of his ebullient enthusiasm.

Sir John Frazer's monumental work *The Golden Bough* proposed that early religions were based on man's mystical interpretation of the mystery of growing crops. The central figure was usually a corn goddess. She was represented by, and often identified with, a priestess. To ensure the fertility of the crops, a man was chosen to be her husband for a year. At the end of that time he became a human sacrifice and his remains possibly scattered over the fields in a fertility rite. Thus his body underwent neither of the two rituals which were normal, those of inhumation or cremation. This interpretation gave a new and more vital meaning to the words of the passage. Once the passage was seen as a dialogue between the priestess and her husband, to be used in a liturgical play, after the human sacrifice had been dropped, new and special meanings were revealed.

With Kosambi's permission I turned his prose translation into a verse translation, since the R̥gveda itself was of course written in poetry. I added two introductory verses to set the scene. For the rest, the translation is quite literal. I have merely added one or two words to each verse to show whether it was the priestess or her fated husband who was speaking.

URVAŚI AND PURŪRAVAS

Out of all men, one man the goddess chooses
As bridegroom for her priestess: one elected
To share immortal loving: one that loses
By force his earthly shape, for heaven selected.
With the immortal goddess he shall lie,
To make her fruitful, and then fruitless die.

After the sacred year, and the many dangers,
The separation and the loss of love,
The mortal and the goddess (no more strangers)
In quiet harmony their passion prove.
But now the darkness comes, and now the fear
Of their strange mating in the sacred year.

Speaks now the mortal: "You who were my wife,
Loving and kind, what transformation now
Changes your beauty? What immortal strife
And what dread purpose marks your lovely brow?
O break your purpose! Let me sing your praise,
Lest dead and fruitless be our distant days."

But, pitiless, the goddess now replied:

"Of what use now your songs? No more you see
The passionate lover or the willing bride.

As the dawn vanishes so vanished she.

The bride's but air, and mortal is the groom;

Return, poor mortal, to your mortal doom."

He spoke again, defiance in his eyes,

(Angry the heart when destiny draws near):

"Look. As an arrow to the quarry flies,

So came I to you, clean of any fear.

Without such courage shall the heart not shine.

The lamb's voice, crying, is no voice of mine."

"You spoke of dawn," he said, "and the dawn each day
Renews her beauty, after the loving night.

In some dark bridal chamber laid away,

Embraced by darkness, rising still more bright.

Such is the power of loving, to renew

The dawn for ever: so my love for you."

"Ah, love," the goddess said, "You did embrace

And take me wholly, as a living fire.

Unwilling was my body, and my face

Turned from you, yet I yielded to your desire.

Though I a goddess, you were king of all

My body's realm, and held me in your thrall."

Then memory stirred within him, and a dream

Of dancing figures on their bridal day,

White figures dancing where the waters gleam;

In the clear pool their image danced as they.

He saw the garlands, and the cattle hung

With sacred flowers. He heard the old songs sung.

She spoke again: "When you were born," she said,

"The wives of all the gods were there, and knew

The destiny prepared, the road you'd tread.

The stream which made the gods have made you too.

Now is the battle joined for which you're made,

Your victory near. Be swift and unafraid."

Again he dreamed: "Once, on a river's side

I saw the nymphs, and touched their nakedness.

From me they started, as the deer that hide

From the swift hunter in the wilderness.

They leap as horses leap, who feel the sting

Of sudden whip and stretch their galloping."

She laughed, remembering: "When a mortal lover,

Young as you then were young, and fair as you,

(But youth and beauty both will soon be over)

Seeks out the nymphs, as once you used to do,

Then—like the swans—they show their beauty gay,

Leaping and running like a horse at play."

"But then you came," he said, "with joy and laughter,

Made me forget my nymphs, and made me run

From their false rivers to the true clear water

Which my heart craved. Your body bears my son.

One further wish I ask you now to give,

Goddess and wife—O let your lover live!"

"Great was your birth" she said, "and great your power.

But all your greatness did you give away,

Yielded to me upon our bridal hour;

I warned you truly on that selfsame day.

You did not heed. Impatient was your passion.

Possession won, your heart has changed its fashion."

"Cruel!" he said, "and must my unborn son,

Asking for me across the fruitless years,

Hear of my fate, and feel the hot tide run

Of sorrow, and the flood of bitter tears?

By what right do you now attempt to part

Husband and wife, kind heart from loving heart?"

"Your son shall weep indeed," the goddess said,

"Until he learns my office. Then shall he,

Knowing your fate and mine, be comforted.

Go pray no more, but meet your destiny.

You found, in love, a mortal lip and brow.

The mortal fool may touch no goddess now."

"Out of your mercy," he replied, "I may

Neither my joy nor even my life recover.

Since love is gone, let life itself give way.

If love be dead, O perish then the lover.

Dharmanand Kosambi

My flesh the wolves shall eat when I shall die.
If not with you, then with cold death I'll lie."

"That lovely flesh," she said, "no wolves shall eat.
Neither with me, nor yet with death you'll lie.
Strange is your fate, and when your hour's complete,
You'll know the secret of your destiny."
"In woman's heart no man shall find a friend,"
He said, "the wild beast dwells there in the end."

"No woman I," she said with darkening eyes,
"Though as a woman did I dwell with you,
A goddess, still, though in a different guise.
My passions many though my feastings few.
Fasting I waited in my mortal dream,
Tasting a little curd, a little cream."

Then he submission made and said: "Prepare
The sacrifice, my goddess, and receive
This mortal flesh, O you who fill the air.
I take my destiny and do not grieve.
Blessings be yours for all our sacred year.
And yet, turn back, my heart is hot with fear!"

Now, all her mortal semblance cast away,
Goddess entire, she spoke: "Because you die,
The gods shall bless you, and your son shall pray,
Serving the gods with holy piety.
Priest, King, and god he shall be by your deed,
And for your blessing shall the gods take heed."

(The above is a version of RV. X. 95 as interpreted by KOSAMBI in *JBBRAS* 27, 1951, pp. 1-30, with two introductory verses; the rest constitute an attempt to reconstruct the ritual described in the *R̥gveda* and the original, actual sacrifice from which the hymn was derived.)

Death overtook Prof. D. D. Kosambi in his bed in the early hours of the 29th June 1966 prematurely and almost surreptitiously, after he had been declared generally fit on the previous day by his family doctor. It was a case of myocardial infarct. A glance at the list of his publications given elsewhere will bring home to us the serious loss the world of progressive and talented writers has suffered and the void his death has left among the leading savants of renascent India.

Born at Kosben in Goa, then under the rule of the Portuguese colonialist, Damodar Kosambi was brought up in a family known for its rigorous standards of learning and social behaviour. He had inherited from his father, the renowned Buddhist scholar: Dharmanand Kosambi, an insatiable spirit of inquiry, a love of wandering and a sharp, versatile intellect, which took him quickly ahead of his coworkers and gave his views a rare sense of originality. After some schooling in India, his father, who had accepted a teaching assignment at Harvard (U.S.A.), took him to the Cambridge Latin School, where as a boy of eleven he dedicated himself to a student's hard life until after about eight years we see him emerging as a brilliant young graduate of the Harvard University in Mathematics, History and Languages. On returning to India he worked for a few years at the Banaras Hindu University and then at the Aligarh Muslim University before he decided to settle down in Poona in 1932 as Professor of Mathematics at the Fergusson College,—known for its pioneering services in the field of National Education, and where father had taught for many years and laid the foundations of Buddhist Studies in Western India. It was during the crucial period of fourteen years he spent at this College, which he in lighter vein characterized as "Rama's exile into the wilder-

ness", that Prof. Kosambi carried on an incessant struggle for mastery in various fields of knowledge and laid the foundations of his greatness as a scholar and a thinker.

Endowed with a powerful and far reaching imagination and an outstanding mathematical ability, Kosambi, who had concentrated his mind almost exclusively upon mathematical research upto 1939, was gradually led to use his abstract methods for obtaining new results in various branches of social sciences. He began by applying statistical methods to Indian numismatics. He was seen weighing with the utmost precision and unremitting zeal thousands of punch-marked coins obtained from different Museums in the country and thrashing out his data until he could establish their chronological sequence, forward convincing arguments regarding the economic conditions under which they could have been minted, and discover facts about the dynastic history of the pre-Mauryan period, based upon a wide study of the ancient literary sources and his new meteorological findings. The more he examined the productive spirit working behind the panorama of Indian history, the more charmed he was by the manifold aspects of Indian culture, the past as well as the present. While giving mathematical precision to his ideas in the various branches of humanities, he turned almost instinctively to his Sanskrit inheritance. His frank and scholarly estimate of Bhartṛhari's Aphorisms and later of Vidyākara's anthology: *Subhāṣitaratnakōśa* was a standing testimony to his versatile genius and quick mastery of the latest advances in literary criticism. In these and other Indological studies covering a wide range of subjects from the Vedic and the Epic to the classical literature of India he owed as much to Sukthankar's Prolegomena to the critical edition of the Mahābhārata as to the most modern standards of literary criticism in the West.

Being deeply preoccupied with the entire field of knowledge as it were it was no wonder that his mathematical lectures in the Fergusson College seemed to go well over the heads of the post-graduate candidates. That as a result of this Kosambi had to leave the College, ought to open our eyes to the dangers involved in our borrowing an examination-ridden system and uninspiring standards of education in this country. The width of his comprehension and his penetrating researches, however, had been making their mark among the scientific circle of India and abroad. It was not long before he was offered the Chair for Mathematics in the Tata Institute of Fundamental Research of Bombay in 1946 which he held for the next 16 years. The new position offered him opportunities of developing closer contacts

with scholars of his own calibre all over the world and of meeting his financial responsibilities better than before. Kosambi, however, could not relish the conditions under which he had to work. Living in his own house in BORI Colony Poona, he had to march every morning to the Railway Station and make the "Deccan Queen" his second home in order to attend to his duties in Bombay. Besides, a man of his temperament, solely dedicated to the pursuit of knowledge and social enlightenment was entitled, he thought, to a freedom of thought and action, such as we hardly expect to meet with in an emergent society struggling for its economic independence. All the same, he was able now not only to give a final shape to some of his earlier studies, but to launch upon new orientations in the fields of Biology, Archaeology, Anthropology and pre-History. And every now and then we see him turning back from his study of the social sciences to the development of his research in the comparatively abstract or pure fields of science: the last book he sent out for publication dealt with Prime Numbers. His last major work: *The Culture and Civilization and Ancient India* (London, 1965), which has now come to be translated into several European and Asiatic languages, set the seal of recognition on his vast erudition, his ability to discover basic motives of human civilization and his brilliant powers of exposition.

It is not for us to estimate the scientific advances made by Prof. Kosambi in the fields of Genetics, Statistics and Mathematics or the part played by him in various other spheres of activity, e.g., in his capacity as Member of the World Peace Council visiting the socialist countries of the East and the West. He believed in the Marxist method of interpreting and changing the human society, but did not hesitate to revise the data of Marx himself in the light of modern research. As an independent thinker with a passionate devotion to scientific research, he seemed to be almost exclusively preoccupied with his own intellectual pursuits. As such he was sometimes accused of brusqueness and intolerance, but he had obviously no use, nor time for all the sophistications of our normal social life, nor could he afford to waste his energies on empty rituals and ceremonies, except for treating them as objects of his anthropological studies. And yet, whenever he found some time to relax, his childlike simplicity and sparkling wit were most refreshing even to those who were nearest to him and he spread laughter and sunshine around him. Towards his friends he was generous to a fault. His inner life was marked by an unmistakable streak of asceticism, while his ethical standards were unusually high and

severe. Prof. D. D. Kosambi deserves to be remembered as one of the highly gifted and versatile scientific workers and indefatigable scholars of modern India for whom a relentless search for the highest human values was the only natural way of life.

(based on his own notes brought up to date by Shri R. P. Nene)

1. Precessions of an elliptical orbit: *Ind. Journ. Phys.* 5. 1930. 359-364.
2. Modern differential geometries: *ibid.* 7. 1932. 159-164.
3. On a generalization of the second theorem of Bourbaki: *Proc. Acad. Sci. of the U. P.* 1. 1931 (3 pages).
4. On the existence of a metric and the inverse variational problem: *ibid.* 2. 1932. 17-28.
5. On differential equations with the group property: *J. Ind. Math. Society* 19. 1932. 215-219.
6. The problem of differential invariants: Jubilee memorial volume of the *J. Ind. Math. Soc.* 20. 1933.
7. Geometrie differentielle et calcul des variations: *Rendiconti d. R. Accad. Naz. d. Lincei.* 1932. 410-415 (communicated by T. Levi-Civita).
8. Affin-geometrische Grundlagen der Einheitlichen Feldtheorie: *Sitz. Preuss. Akad. Wiss. Phys. Math. Klasse.* 1932. 342-345. Communicated by Erhard Schmidt (misprint in 1st formula 15).
9. Parallelism and path-spaces: *Math. Zeitschrift* 37. 1933. 608-618. The note following on pp. 619-622 of the same issue by Elie Cartan should be read jointly with the paper.
10. The classification of Integers: *J. Uni. Bombay.* 2. 1933. 18-20 (merely expository).
11. Collineations in path-space: *J. Ind. Math. Soc.* 1. 1934. 69-72.
12. Continuous groups and two theorems of Euler: *Math. Student* 2. 1934. 94-100.

13. The maximum modulus theorem: *J. Uni. Bombay* 3. 1934. 11-12 (proof that the theorem holds for non-analytic functions provided only that they are *schlicht* in the mapping).
14. Systems of differential equations of the second order: *Quart. J. Maths.* (Oxford), 6. 1935. 1-12. (Einstein-Mayer field equations on P. 7; identities on pp. 9-10 used by Douglas, *Proc. Nat. Acad. Sci. (U.S.A.)* 1939 et. seq., without acknowledgement).
15. Homogeneous metrics: *Proc. Ind. Acad. Sci.* 1. 1935. 952-954. Shows that certain types of connections might admit only a metric homogeneous of degree zero, not of Finsler type).
16. An affine calculus of variations: *Proc. Ind. Acad. Sci.* 2. 1935. 333-335 (extension of tensor analysis to higher order differential equations).
17. Differential geometry of the Laplace equation: *J. Ind. Math. Soc.* 2. 1936. 141-143. (It was later pointed out by T. Levi-Civita in a friendly letter that the essential results had been obtained by him before 1907, and Emile Cotton in 1913.)
18. Path-spaces of higher order: *Quart. J. Maths.* (Oxford). 7. 1936. 97-104. (Actual execution of the ideas of 16; basis for the work of V. Seetharaman, *Proc. Lond. Math. Soc.* 1938; also frequently utilized by Kawaguchi, Hombu, Hokari, Ohkubo and other members of the Japanese school of differential geometry and tensor analysis.)
19. Path-geometry and cosmogony: *Quart. J. Maths.* 7. 1936. 290-293. (First application of the new methods developed in nos. 7, 9, 14, 15 to Milne's work. The divergence of points of view led to misunderstanding and polemical criticism, on both sides.)
20. Les metriques homogenes dans les espaces cosmogoniques: *Comptes Rendus* (Paris) 206. 1938. 1086-1088.
21. Les espaces des paths generalises qu'on peut associer avec un espace de Finsler: *ibid.* 1538-1541. Development of 20. (The theoretical bases for reverting from Milne's paths to a metric, and a complete set of conditions for associating a metric in n -space with that in an $n+1$ -space, logically necessary for any theory of relativity.)
22. The tensor analysis of partial differential equations: *J. Ind. Math. Society* 3. 249-253. But the Japanese translation appeared first as in the journal: *Tensor*, No. 2, Aug. 1939. 36-39 (Translation by H. Hashimoto), followed by a comment in Japanese by A. Kawaguchi.
23. A note on the trial of Sokrates: *Fergusson Coll. Mag.* July 1939, 1-6 (Sokrates and the class-war of his day); Reprinted in 109, below.
- 24-25. Various reviews in *The New Age*, *National Front*, and related publications. J. B. S. Haldane on *Marxist philosophy and the sciences*, J. D. Bernal on the *Social functions of science*, G. D. H. Cole and R. Postgate on the *Common people*, etc.
26. The emergence of national characteristics among three Indo-European peoples: *ABORI* 20. 1940, 195-206. Trial speculation on Indology.
27. (a) The function of leadership in a mass movement; (b) The Cawnpore Road: *Fergusson Coll. Mag.* 1939-40, 1-7. (A critique of dialectical-materialistic social theory; a story published under the pseudonym "Ahriman" reprinted in 109, below.)
28. (a) Revolution and the progress of science: *New Age* 5. 320-325. (A survey of the effects of the revolution upon mathematics in the USSR.)
28. (b) Science learns the goose-step: *ibid.* pages unknown, as the journal was suppressed soon after. (A protest against the dismissal of T. Levi-Civita from the editorship of the *Zentralblatt fur Math.* and subsequently from all Italian academies, on grounds of his being a Jew.)
29. Path-equations admitting the Lorentz-group-1: *J. Lond. Math. Soc.* 15. 1940. 86-91, reprinted (for the offprints), *Fergusson Coll. Mag.* February 1941.
30. A statistical study of the weights of old Indian punch-marked coins: *Current Science* 9. 1940. 312-314.
31. The concept of isotropy in generalized path-spaces: *J. Ind. Math. Soc.* 4. 80-88. (With an application to Milne's cosmology in the final portion.)
32. A note on two hoards of punch-marked coins found at Taxila: *New Ind. Antiquary* 3. 1940, 156-157. (A review of the memoir by E. H. C. Walsh on the subject.)
33. A note on frequency distribution in series: *Math. Student* 8. 151-155. (Methods of generating other distributions than the Poisson and the binomial); see no. 75 and no. 108.
34. (a) On the study and metrology of silver punch-marked coins: *New Indian Antiquary*, 4. 1941. 1-35 and 49-76. (Numismatics as a science, with an application to its

- most difficult problem.) (b) Additions and corrections, *ibid* 5. 1942, May.
35. A bivariate extension of Fisher's Z-test: *Current Science* 10. 1941. 191-192. (The precise analogue, by readjusting the degrees of freedom, of Fisher's z-test, for a bivariate population.)
 36. Correlation and time-series: *ibid.* 372-374. (Pointing out that the correlation coefficient is meaningless if calculated when the variance of one of the two variates is infinite.)
 37. The quality of renunciation in Bhartṛhari's poetry: *F. Coll. Mag.* 1941. (A study in comparative literature. Republished with changes in *Bhāratiya Vidyā* 1946. 49-62; reprinted in 109, below.)
 38. Path-equations admitting the Lorentz group-II: *J. Ind. Math. Soc.* 5. 1941. 62-72. (Continuation of 29; for further work, see the series of papers by Mohd. Shabbar, *Proc. Ind. Acad. Sci.* 1940, 1941.)
 39. On the origin and development of silver coinage in India: *Current Science* 10. 1941. 395-400. Shows that the punch-marked coinage system developed from Mohenjo-Daro cut silver pieces.
 40. On valid tests of linguistic hypotheses: *New Indian Antiquary* 5. 1942. 21-24. Shows that Zipf's "inverse square" law is not valid in linguistics. This paper was then called to the special attention of linguists by A. J. Lotka.
 41. Zeros and closure of orthogonal functions: *J. Ind. Math. Soc.* 6. 1942. 16-24.
 42. The effect of circulation upon the weight of metallic currency: *Current Science*. 11. 1942, 227-231. Shows linear decrease of weight with use of coins; independence of correlation and denomination; continuation of 34 for modern coins.
 43. A test of significance for multiple observations: *Current Science* 11. 1942. 271-274. A tentative approach to statistics in function-space.
 44. Progress in the production and consumption of textile goods in India: *J. Ind. Merchants' Chamber* (Bombay), Jan. 1943, 11-15. Published as by "Vidyarthi" and Miss Sushila Gokhale.
 45. Race and immunity in India: *New Indian Antiquary* 6. 1943. 29-33. Shows that the supposed immunity of the Hunzas is due to a rigorous climate as Darwinian selective agency.
 46. Statistics in function space: *J. Ind. Math. Soc.* 7. 1943. 76-88. Shows how statistics may be extended to a population of functions by using orthogonal functions and integral equations.
 47. The estimation of map distance from recombination values: *Annals of Eugenics* 12. 1944. 172-175.
 48. Soviet victory and the world revolution: *Indo-Soviet Journal* 2. (Nov. 7, 1943), p. 6. Shows that the theory of world revolution had not been abandoned by the USSR, as of that date.
 49. The Parvasamgraha of the Mahabharata: *JAOS*, 66 (2), 1946, 110-117; followed by the counts of E. D. Kulkarni, *ibid*, 118-144. First complete discussion of the problem and of V. S. Sukthankar's concept of a "fluid text".
 50. The geometric method in mathematical statistics: *Am. Math. Monthly* 51. 1944. 382-389. Derivation of all elementary distributions by the geometric method first introduced by R. A. Fisher.
 51. The Law of large numbers: *Math. Student* 14. 1946. 14-19.
 52. The change in the Soviet constitution: *Indo-Soviet Journal* 2. (9). 1944.
 53. Direct derivation of series spectra: *Current Science* 13. 1944. 71.
 54. Caste and class in India: *Science and Society* 8. 243-249. Comment on an article by P. Rosas on the subject.
 55. Parallelism in the tensor analysis of partial differential equations: *Bulletin Am. Math. Soc.* 51, 1945, 293-296.
 56. Soviet Science: What can it teach us? *Indo-Soviet Journal* 11-13. June 22, 1944.
 57. George David Birkhoff: 1884-1944 (Obituary). *Math Student* 12. 1944. 116-120.
 58. The Raman effect (Anonymous, as by an "Indian Scientist"), *People Age*. July 22, 1945.
 59. Some extant versions of Bhartṛhari's *Śatakas*: *JBBRAS* 21. 1945. 17-32.
 60. On the authorship of the *Śatakatrayī*: *JOR* (Madras) 15. 1946. 64-77.
 61. *The Śatakatrayam of Bhartṛhari with the commentary of Rāmarṣi*, edited in collaboration with Pt. K. V. Krishnamoorthi Sharma, Poona, 1945, 2 + 140 + 6 + 1, Anandashrama Sanskrit Series, no. 127.

62. The Village community in the "old conquests" of Goa: *J. Uni. Bombay* 15 (4). 1947. 63-78.
63. Sur la différentiation covariante: *Comptes Rendus* (Paris) 222. 1946. 211-213.
64. Silver punch-marked coins with special reference to the East Khandesh Hoard: *J. Num. Soc. Ind.* 8. 1946. 63-66.
65. Early stages of the caste system in northern India: *JBBRAS* 22. 1946. 33-48.
66. *The Southern Archetype of Epigrams ascribed to Bhartrhari*. Bharatiya Vidya Series 9, Bombay, 1946. 176 + 13 + 8. The first critical edition of any Bhartrhari recension.
67. An extension of the least-squares method of statistical estimation. *Annals of Eugenics*, 13, 1947, 257-261.
68. Parvasamgraha figures for the Bhīṣma-Parvan: (with E. D. Kulkarni) *JAOS* 71. 1951 21-25.
69. Some applications of the functional calculus. (Presidential Address to the Mathematics Section of the Indian Science Congress, Delhi, Jan. 1947, completely ruined in the printing; no proof shown to the author).
70. Les invariants différentiels d'un tenseur covariant a deux indices: *Comptes Rendus* 225, 1947. 790-792. Also Differential invariants of a two-index tensor, *Bull. Am. Math. Soc.* 55. 1949. 90-94.
71. Early Brahmins and Brahminism: *JBBRAS* 23. 1947. 39-46.
72. Systems of partial differential equations of the second order. *Quart. J. Math.* 19. 1948. 204-219.
73. *The Epigrams Attributed to Bhartrhari*. (Singhi Jain Series 23) Bombay, 1948; pp. viii + 82 + 240. This is the first comprehensive edition of the poet's works and still remains the editio princeps, being cited in books on Indian text-criticism as a landmark in critical methods.
74. Chronological order of punch-marked coins—I: *JBBRAS*, 25. 1948-9, 33-47.
75. Characteristic properties of series distributions. *Proc. Nat. Inst. Sci. (India)* 15. 1949. 109-113; see no. 33; sequel in no. 108.
76. Lie Rings in Path-space: *Proc. Nat. Acad. Sci. (U.S.A.)* 35. 1949. 389-394.
77. The Avatāra syncretism and possible sources of the *Bhagvad-Gītā*: *JBBRAS* 24-25. 1948-49, 121-134.
78. Marxism and ancient Indian culture (adverse review of S. A. Dange's "India from Primitive Communism to Slavery"): *ABORI* 29. 1949. 271-277. Reprinted in *India Today*.
79. On the Origin of Brahmin Gotras: *JBBRAS* 26. 1950. 21-80.
80. Series Expansions of continuous Groups: *Quart. J. Math.* (2). 2. 1951. 244-257.
81. Chronological order of punch-marked coins-II: The Bodenāyakanūr Hoard: *JBBRAS* 26. 1951. 214-218.
82. Urvaśī and Purūravas: *JBBRAS* 27. 1951. 1-30. Reprinted in *Indian Studies: Past & Present*, vol. 1. Calcutta 1959. 141-175, and in no. 122 below.
83. On a Marxist approach to Indian chronology: *ABORI* 31. 1951. 258-266.
84. Seasonal variations in the Indian birth-rate (with S. Raghavachari): *Ann. Eugenics* 16. 1951. 165-192. Cited for use of polar coordinates in periodic biological phenomena. Presents considerations on birth control also.
85. Path-spaces admitting collineations: *Quart. J. Math.* (2) 3. 1952. 1-11.
86. The Cintāmaṇi-sāraṇikā of Daśabala: *Supplement to JOR* (Madras), 1952, 8 + 15; edition of a Sanskrit astronomical work, which shows incidentally that king Bhoja of Dhārā died in 1055-6.
87. The Sanskrit equivalents of two Pali words: *ABORI* 32. 1952. 53-60. Gives the correct derivation of *sammappāso* and *vassakāra*.
88. Path-Geometry and continuous groups: *Quart. J. Math.* (2) 3. 1952. 307-320.
89. Imperialism and Peace: *Monthly Review*. 3. 1951. 45-49.
90. Ancient Kosala and Magadha: *JBBRAS* 27. 1952. 180-213.
91. Science and freedom: *Monthly Review* 4. 1952. 200-205; in longer form *Vijñān-Karmee* 4. October 1952. 5-11.
92. Geldner's *R̥gveda*: *JOR* (Madras), 1952, 291-295 (essay review, with special attention to words like *ibhya*).
93. Chronological order of punch-marked coins-III: The Paila Hoard: *JBBRAS* 27. 1952. 261-271.
94. Brahmin clans: *JAOS* 73. 1953. 202-208. Review and critique of J. Brough's book: *The early brahmanical system of gotra and pravara*, (Cambridge, 1953). Mistaken for a polemic.
95. Seasonal variation in the Indian death rate (with S. Raghavachari): *Annals of Human Genetics* 19. 1954. 100-119; complements no. 84 above.

96. The Periodization of Indian History. *ISCUS* 1, 1954, pp. 40-55. (Arbitrarily changed by the editors, without consulting the author.)
97. Notes on the class structure of India: *Monthly Review* 6. 1954, 205-213; see 109, below.
98. The metric in path space: *Tensor* (New Series), 3. 1954. 67-74.
99. What constitutes Indian History? *ABORI* 35. 1955. 194-201. Essay review of the first three volumes of the Bhāratiya Vidyā Bhavan's History of India.
100. The basis of ancient Indian history — 1: *JAOS* 75. 1955. 35-45; II, *ibid.* 226-237.
101. The working class in the *Amarakośa*: *JOR* (Madras) 24. 1955. 57-69. Shows the existence of a hierarchical principle in the *Amarakośa* classification.
102. Origins of feudalism in Kaśmīr: *JBBRAS* (Sārdhaśatābdi volume). 1956-7. 108-120.
103. Indo-Ariiskii Nosovoi Ukazatel': Sovetskaya Etnografia (Ak. Nauk USSR), No. 1, 1958, 39-57. Demonstrates the unreliability of nasal-index data in theorising about Indian racial groups.
104. On the development of feudalism in India: *ABORI* 36, 1956. 258-269; adverse critique of Soviet Professor K. A. Antonova's theories.
105. The method of least squares: (Chinese text, Ac. Sinica, unknown publication, in 1957). *Journal of the Ind. Soc. Agricultural Statistics* 11. 1959. 49-57. Solves abstract equations, including integral equations for atomic piles (diffusion).
106. The *Subhāṣitaratnakośa* of Vidyākara (ed. with V. V. Gokhale *HOS*, 42, 1957. The oldest known general anthology of classical Sanskrit verse. A fragment was edited by F. W. Thomas under the erroneously conjectured title *Kavindra-vacanasamuccaya* (Calcutta, 1912).
107. *Introduction to the study of Indian History*. Popular Book Depot, Bombay, 1956. See particularly the reviews by A. L. Basham (*BSOAS*), D. H. H. Ingalls (*JAOS*) L. Renou (*JA*).
108. Classical Tauberian theorems: *J. Ind. Soc. Ag. Stats.* 10, 1958, 141-149. Points out intimate connection with probability distributions, leading to improved methods.
109. *Exasperating Essays*: People's Book House, Poona, 1957. Republication of nos. 23, 27, 37, 97 above; and some other writings.
110. The efficiency of randomization by card shuffling. (With U. V. R. Rao). *J. Royal Stat. Soc.* 121-ii. 1958. 223-233. Analysis of statistical defects underlying para-psychological experiments.
111. Dhenukākaṭa: *JBBRAS* 30. 1957. 50-71. Identification of the ancient Greek colony in Maharashtra. Also, complete text and translation of all known Brāhmi inscriptions in Māval caves, including one from Kārle hitherto unpublished. The first photograph of the Sphinx on a Kārle pillar.
112. The text of the *Arthaśāstra*: *JAOS* 78, 1958, 169-173. Shows that about a quarter of the original work is lost, but more or less uniformly over the whole text.
113. The basis of despotism: *Economic Weekly* (Bombay) Nov. 2, 1957; pp. 1417-9. Review of K. A. Wittfogel's *Oriental Despotism*.
114. Notes on the Kandāhār edict of Aśoka: *JESHO* 2. 1959. 204-6.
115. China's communes: *Monthly Review* 10. 1959. 425-429.
116. Primitive communism: *New Age* (Monthly) 8 (2) Feb. 1959; pp. 26-39. First treatment of 'communism' in primitive society, without idealization of ethnographic data.
117. Social and Economic Aspects of the *Bhagavad-Gītā*: *JESHO* 4. 1961. 198-224. Revision of an article originally published in *ENQUIRY* 2, 1959, 1-20.
118. Indian feudal trade charters: *JESHO* 2. 1959, 281-293. Special treatment of the Viśnusena charter of 592 A.D. correcting D. C. Sircar's gruesome mistakes.
119. An application of stochastic convergence: *J. Ind. Soc. Ag. Stats.* 11, 1959, 58-72; shows that if the primes in suitably defined covering intervals behave like an unbiased random sample, then the Riemann hypotheses follows.
120. At the crossroads: *JRAS* (London) 1960, 17-31; 135-144. Russian translation in *Indicheskii Etnograficheskii Sbornik* (1961) 45-65.
121. Kaṇiṣka and the Śaka era: *Marg*, April 1962; also *JBBRAS* 1962. 35, 36-37. Originally presented and accepted as a late paper to the Kaniska conference, SOAS, London. April 20-22, 1960. Identifies Kaṇiṣka I with Soter Megas and Kaṇiṣka II with the king of the coins.
122. *Myth & Reality/Studies in the formation of Indian Culture*, Bombay, 1962. Reprints of nos. 117, 82, 120, and 62 with illustrations, an introduction, with a new chapter

- on the prehistory of Maharashtra, based on the writer's own field-work.
123. Pierced microliths from the western Deccan plateau: *MAN* Jan. 1962, note 4, pp. 10-12. Apparently the first announcement of such microliths.
 124. Megaliths in the Poona District: *MAN*, May 1962; note no. 108, pp. 65-7 + plate.
 125. The sampling distribution of primes: *Proc. Nat. Acad. Sciences (USA)* 49. 1963. 20-23. Shows that the primes numbers in intervals of fixed length on the real line transformed by $y = \text{li}(x)$ occur in a Poisson distribution.
 126. Combined methods in Indology: *Indo-Iranian Journal* 6. 1963. 177-202. By special invitation of the editors, to show that philology, history, archaeology and anthropology have to be combined to get valid results in any one of these fields; which, treated in isolation, leads to wrong conclusions otherwise.
 127. Adventure into the unknown: *Asian Thought*. (A note on the writer's personal philosophy as a scientist and research worker; by invitation of the editors, in a symposium by the Andhra University Dept. of philosophy; yet to appear in print.)
 128. Prehistoric Rock Engravings near Poona: *MAN* April 1963, note 60, pp. 57-8.
 129. The autochthonous element in the *Mahābhārata*: *JAOS* 84 31-44.
 130. Statistical methods in number theory: *J. Ind. Soc. Ag. States*, 16. 1964. 126-135.
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To Indian history and culture, Kosambi's *Introduction to the Study of Indian History* marks a new stage in Indian historiography. To write it, he did pioneering work in numismatics, archaeology and ethnography, showing that mere written sources would not suffice. Kosambi was invited by the University of London (under the sponsorship of the British Council, and the London School of Oriental Studies), for a series of lectures on Indian history and was specially invited to participate in the next International Congress of Orientalists. The bibliography of his writings lists over a hundred entries comprising several books and a number of original papers.